The N. C. Agricultural Experiment Station

1903—1904

TWENTY-SEVENTH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

YEAR ENDING JUNE 30, 1904

INCLUDING

SCIENTIFIC PAPERS, AND BULLETINS Nos. 186, 187, 188, 189

RALEIGH, NORTH CAROLINA

RALEIGH:
PRESSES OF EDWARDS & BROUGHTON.
1905.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

S. L. Patterson, *ex officio* Chairman, Raleigh.

J. M. Forehand ..... Rockyhock	A. T. McCallum ..... Red Springs
J. B. Stokes ..... Windsor	J. P. McRae ..... Laurinburg
Wm. Dunn ..... New Bern	R. L. Doughton ..... Laurel Springs
C. N. Allen ..... Auburn	W. A. Graham ..... Machpelah
R. W. Scott ..... Melville	A. Cannon ..... Horse Shoe

STATION STAFF.

Geo. T. Winston, L.L. D., President of the College.

B. W. Kilgore ..... Director.
W. A. Withers ..... Chemist.
W. F. Massey ..... Horticulturist.
C. W. Burkett ..... Agriculturist.
Tait Butler ..... Veterinarian.
F. L. Stevens ..... Biologist.
Franklin Sherman, Jr ..... Entomologist.
W. G. Morrison ..... Assistant Chemist.
J. S. Jeffrey ..... Poultryman.
B. F. Walton ..... Assistant in Field Experiments.
J. C. Kendall ..... Assistant Dairy Husbandry.
A. F. Bowen ..... Bursar.

The Director's Office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C

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LETTER OF TRANSMITTAL.

RALEIGH, N. C., June 30, 1904.

To His Excellency, CHARLES B. AYCOCK,
Governor of North Carolina.

SIR:—I have the honor to transmit herewith the report of the operations of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year beginning July 1, 1903, and ending June 30, 1904.

Very respectfully,

S. L. PATTERSON,
Chairman Board of Trustees.

LETTER OF SUBMITTAL.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,

RALEIGH, N. C., June 30, 1904.

HON. S. L. PATTERSON, *Chairman Board of Trustees.*

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year ending June 30, 1904.

Trusting that this report will prove satisfactory, I am,

Very respectfully,

B. W. KILGORE,
Director.

TWENTY-SEVENTH ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30th, 1904.

By the Director.

This report covers the work of the Experiment Station from July 1, 1903, to June 30, 1904.

CHANGES IN STATION STAFF.

Dr. G. S. Fraps, assistant chemist, resigned early in the year to accept a position in the Texas Experiment Station, and Mr. W. G. Morrison was appointed to succeed him.

WORK IN THE AGRICULTURAL DIVISION.

The fertilizer, culture and variety tests with cotton and corn, and the experiments with grasses for pasture and for hay, described in detail in the report for 1902, and referred to in the report for 1903, have been continued in order to collect further data on these subjects. The results will be published when it is felt that sufficient material has been obtained to throw light on the subjects under investigation.

Some further work has been added along the lines included in the report of the Agriculturist.

WORK IN THE CHEMICAL DIVISION.

For several years past the Chemical Division has been engaged in a study of the rate at which various nitrogenous fertilizer materials nitrify and become available for plant food. In working with different type soils it was found that they exerted marked influence on the results. This led to the development of what seems to be a promising method of comparing the nitrifying powers of different soils. The study has been extended to include phosphoric acid and potash, with a view to ascertaining their availability and the means of increasing it.

Some further experiments have been added on the effect of salt upon the moisture content of soils and the formation of humus in the soil.

WORK IN THE HORTICULTURAL DIVISION.

The tests of varieties of grapes, apples, peaches, pears and plums, and a number of kinds of garden vegetables are being continued.

Special efforts are being made to produce, by breeding and selection, a better variety of sweet corn. Flowering bulbs have received a good deal of attention at the hands of the Horticulturist. A considerable number of these are already being grown in the eastern part of the State as a result of the efforts of the Station, and it is felt that there is sufficient promise in the future to justify a continuance, and if possible, an extension of the work in this line. A considerable amount of the Horticulturist's time is taken up in correspondence with the farmers of the State and in the conduct of Farmers' Institute work when called on by the Department of Agriculture for help.

WORK IN THE BIOLOGICAL DIVISION.

This Division is devoted mainly to the study of plant diseases. The spring and summer months of 1904 were specially favorable to the development of plant diseases, and the Biologist reports that an enlarged number of inquiries came to him during the season for the identification of diseases and for suggestions for the treatment of them. A large number of trucking and farm crops were affected, especially cotton, tobacco, melons, peaches, pears, lettuce, etc.

The experiments with tobacco wilt in Granville County were continued and included tests of a large number of varieties of tobacco and possible remedies for preventing the disease. Nothing definite, however, has as yet been obtained, though the experiments are promising and will be continued, in the hope of finding a variety of tobacco which will resist the wilt, or a method for preventing the disease. It is found that the disease is easily transplanted from one field to another in a number of ways, and that the infected area is gradually spreading.

In co-operation with the Bureau of Plant Industry of the United States Department of Agriculture, an experiment was conducted near Garner with a large number of varieties of watermelons, in an effort to produce one or more kinds of wilt-resistant melons of good marketable quality. The results of the experiment are promising. Two or three kinds of melons were obtained which are wilt-resistant and of good quality. These experiments will be continued. The wilt disease of this crop is spreading in the State, and is especially bad in the area between Raleigh and Goldsboro.

WORK IN THE POULTRY DIVISION.

Mr. Jeffrey has now been in charge of the work almost a year and a half. The new buildings and runs for the poultry referred to in the last report have been completed and the plant is fairly well equipped for work in this line. The plant is well stocked with good birds of nine of the utility breeds. At exhibitions at the poultry shows the fowls have scored well. Practically all the surplus stock and eggs

which could be spared have been disposed of, thus getting into the hands of the citizens of the State better fowls. Experiments are being conducted in methods of feeding and in preservation of eggs. A record is being kept of the egg production from the different breeds to help determine the merits of the different kinds. Eggs from the largest layers of the different breeds are being kept separate, with a view of further increasing the number of eggs. One Bulletin on general poultry culture has been prepared and published, and a special one on feeding and methods of preserving eggs will soon go to the printer. There has been a large increase in the amount of poultry grown in the State, and the correspondence which comes to the Station shows that there is much interest in this subject.

WORK IN THE ENTOMOLOGICAL DIVISION.

The expenses of the entomological work is met by the Department of Agriculture. A large amount of most valuable and telling work is being done in this line to aid the farmers of the State. Some experimental work is being done in which the Station is paying for the actual cost of materials and extra labor.

FARMERS' INSTITUTES.

The Station has aided the Commissioner of Agriculture in conducting Farmers' Institutes by sending members of the staff whenever called on by him for this service. We consider this a most important phase of agricultural work,—one that should be encouraged and extended in every way possible.

PUBLICATIONS.

Bulletins have been issued as follows:

No. 186—Insect and Fungus Enemies of the Peach, Plum, Cherry, Fig and Persimmon, by F. L. Stevens and Franklin Sherman, Jr.

No. 187—Grapes and Small Fruits, by W. F. Massey.

No. 188—The Granville Tobacco Wilt, by F. L. Stevens and W. G. Sackett.

No. 189—Feeding Farm Horses and Mules, by C. W. Burkett.

And Press Bulletins as follows:

No. 9—To Prevent the Black Rot of the Grape.

No. 10—The Watermelon Wilt.

No. 11—A Dangerous Tobacco Disease.

No. 12—Black Rot of the Cabbage.

No. 13—Silk Growing.

REPORTS OF HEADS OF DIVISIONS AND FINANCIAL STATEMENT.

The reports of the heads of the several divisions of the Station's workers and financial statement follow.

REPORT OF THE AGRICULTURAL DIVISION.

PROF. B. W. KILGORE:

DEAR SIR:—During the past year the Station work in this Division has been centered along the same lines as outlined in last year's report. The experiments are planned to extend through a series of years, with the idea of obtaining information of practical as well as fundamental bearing.

Considerable land has been cleared the past three years, thus enlarging the area devoted to Station work and now making it sufficient for the needs of the Division.

AGRONOMY AND PLANT PRODUCTION.

Several hundred plats are now being used for investigation in agronomy and plant production in the following lines of work:

1. *Grasses and Forage Crops*—

Many of the principal grasses and forage crops have been tested. The vetches, clovers, cowpeas, soja beans, Newman beans, corn and Bermuda have all done splendidly, and suggest good possibilities for the live-stock husbandry for the State.

2. *Cowpeas*—

These have been tested in reference to time of planting, quantity of seed, methods of planting, varieties and fertilization. Cowpeas are also being studied in their relation to soil improvement.

3. *Wheat*—

Wheat culture in relation to cowpeas, varieties of wheat, and time of planting are involved in the present tests. The Division is planning to include experiments with fertilizers in the near future.

4. *Corn*—

The experiments with this crop are reasonably extensive in nature to cover the important factors incident to corn culture. The tests include the fertilization of corn, rotation of crops in reference to corn growing, time of planting, variety tests, quantity of seed and distance in planting.

5. *Soja Beans*—

Experiments with soja beans include fertilizer tests, varieties, quantity of seed, methods of planting, effect of liming, etc. This work was begun last year.

6. *Cotton*—

Tests along the same line as corn are being conducted with cotton.

7. *Alfalfa*—

Work with this crop consists of testing spring and fall seeding, and includes fertilizer tests, value and effect of inoculation, effect of liming, etc.

SOIL IMPROVEMENT.

About one hundred and fifty acres of old worn-out lands have been taken up, the scrub pines and oaks cut and fields plowed and kept under a constant rotation. The problem of such lands is receiving a good deal of attention by the Division, and interesting results are at hand.

FEEDING FARM HORSES AND MULES.

This work includes numerous comparisons with feeding stuffs, both roughage and concentrates. Weekly weighing of all animals used in the experiments give reliable data for conclusions.

THE DAIRY INDUSTRY.

Since a good part of the manufactured dairy products used in the State is brought from other States, it follows that the dairy industry is one of great and growing importance. This is doubly so on account of the marvellous development of manufacturing interests in the State. The Division is giving careful attention to dairy education, the improvement of dairy stock, and the production of milk and butter. The whole College herd is used in this investigation. The lines being considered are: The cost of producing milk and butter with Southern feeds, and under Southern conditions; the milk and butter capacity of the dairy cows; comparison of feeding stuffs raised in the State; methods and practice in farm dairying, etc.

A careful record of each cow is being kept. The milk of every cow at every milking is recorded and sampled for determination of butter content. Other phases of dairying are also being studied.

CONCLUSION.

I desire to express my high appreciation of the work of Mr. J. C. Kendall, assistant in dairying, and Mr. B. F. Walton, assistant in agronomy and field work.

Respectfully submitted,

CHARLES WM. BURKETT,
Agriculturist.

REPORT OF THE CHEMICAL DIVISION.

PROF. B. W. KILGORE, *Director.*

SIR:—During the past year the principal work of this Division has been the study of the availability of plant food in the soil, and the means for increasing it.

The availability of plant food in soils is dependent upon several factors, the chief of which are (1) the form in which the plant food is held in the soil; (2) the power of different plants to take plant food from different forms of combination; and (3) the activity of the various agencies at work within the soils which change the forms of combination of the elements during the growing period of the plant.

The attention of chemists has been directed chiefly to the first of these factors, namely, the solubility in different solvents of the plant food in the soil at some particular time. The work of this Division has been in the direction of the third factor, namely, the change of plant food from an unassimilable to an assimilable form. A practical example will illustrate the importance of this factor and may be found in a comparison of the yields for 1903 of Massachusetts and North Carolina soils, as shown by the reports of the United States Department of Agriculture.

YIELDS PER ACRE, 1903.

Crop.	Massachusetts.	North Carolina.
Corn	23.0 bushels.	14.7 bushels.
Oats	31.7 bushels.	11.4 bushels.
Rye	13.7 bushels.	8.8 bushels.
Buckwheat	13.7 bushels.	12.1 bushels.
Irish Potatoes	96.0 bushels.	67.0 bushels.
Tobacco	1400 pounds (Vermont).	610 pounds.
Hay	1.36 tons.	1.60 tons.

The yield per acre of hay, which requires no cultivation, is slightly greater in North Carolina than in Massachusetts, and indicates that the North Carolina soil in its natural state is slightly superior to the soil of Massachusetts. We should expect this, as the soils of the two States have about the same geological history, and the soil of the latter State, being under cultivation for a longer time than the former would naturally be more nearly exhausted.

When we consider the cultivated crops we find a great advantage in favor of the yield of the Massachusetts soil. The census reports do not show a very great difference in the use of commercial fertilizers per acre, the Massachusetts climate can not be considered so favorable for vegetation as that of North Carolina, and hence we are forced to conclude that the principal cause of the difference in yields is in the

cultivation. Comparing the States further in the census reports, we will find that Massachusetts has a great advantage in the amount of money per acre invested in farm implements and in live stock. These two factors mean a more intensive cultivation in Massachusetts and the use of greater quantities of stable manure. This means the liberation of a greater amount of plant food per acre each year in Massachusetts soils.

Availability of Phosphoric Acid in Soils.—Starch and sawdust by decay had no effect upon the amount of phosphoric acid soluble in fifth normal nitric acid according to our experiments. Stable manure after four and eight weeks standing with the soil did not increase, but on the contrary decreased the amount of phosphoric acid soluble in water and in fifth normal hydrochloric acid. There was the same effect with the stable manure fresh or rotted, and with calcium oxide, or calcium carbonate present or absent.

Nitrification in the Soil.—The work of this Division for previous years showed that various nitrogenous substances coming into contact with the soil formed nitrates with varying degrees of rapidity. During the past year, it was found that the organic nitrogen in stable manure, when in contact with the soil, was changed rapidly to nitrates, In no case was there any reduction of nitrates in the soil in this series of experiments.

Availability of Potash in the Soil.—Calcium carbonate and calcium sulphate seem to decrease the amount of potash soluble in fifth normal and in fiftieth normal nitric acid. Decaying organic matter in the form of starch and sawdust increased the amount of potash dissolved by the same solvents. Stable manure standing four and eight weeks had very little effect upon the solubility of potash in distilled water, or in fifth normal hydrochloric acid. Probably longer contact would have shown a greater solubility, judging from the experiments with starch and sawdust.

Formation of Humus in the Soil.—In soils to which starch and sawdust were added, the amount of humus increased slightly at first, and then decreased until the end of the period of the experiment (five and a half months).

Method of Comparing Nitrifying Powers of Soils.—This Division has previously shown that different soils have different powers for supporting the growth of nitrifying organisms, and that the same soil sampled under different atmospheric conditions and at different seasons shows different powers. In the report for the previous year a method was proposed for comparing the nitrifying powers of soils. This method has been tested during the present year in the hands of different workers with results which in some cases agree and in others not, showing that the proposed method is promising but not

perfect. Further study will be given to perfecting it. The study of nitrification, to which attention was attracted to a large extent by the work of this Division beginning in 1899, is being prosecuted by agricultural chemists at home and abroad. As nitrogen is the most expensive element which enters into the production of plants and animals, the farmer will welcome any knowledge which will aid him in increasing its supply or its availability, or in diminishing the sources of its loss.

Effect of Salt Upon the Moisture Content of Soils.—Common salt when added to the soil to the extent of two per cent of the weight of the soil was found to increase the water-holding power of the soil, and to diminish the rate of evaporation of water from soils. Attention was called to this fact by Wollny (Farmers' Bulletin No. 114). In our experiments water was absorbed about thirty-three per cent more rapidly in the soils to which salt was added, and in soils to which twenty per cent of water had been added the evaporation was from twenty to thirty per cent less rapid in the salted than in the unsalted soils.

Co-operation with the Association of Official Agricultural Chemists.—During the year, this Division co-operated with the referees on potash and sulphur, the samples having been sent out for a study of the methods of determining the amounts of those elements in agricultural products.

Change in Staff.—During the year Mr. Morrison accepted a more lucrative position with a company engaged in the manufacture of commercial fertilizers. He carries with him the best wishes of the Station. His successor is Dr. Charles Walker, who received his baccalaureate degree at the University of Tennessee, and the Doctorate in Philosophy at the Clark University, Massachusetts.

Needs of the Division.—The Division is cramped in quarters, needs an additional assistant, and a larger appropriation at its disposal for apparatus and chemicals. It is hoped that all these will be provided in the chemical building, of which the College is sorely in need.

Very respectfully,

W. A. Withers,
Chemist.

REPORT OF THE HORTICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director.*

SIR:—In accordance with your request, I herewith submit my report for the year past.

In the line of experimentation with annual vegetables I have been doing a great deal. I am breeding up by selection two varieties of sweet corn. One of these, known as the Voorhees Red, came from Professor Halsted, of the New Jersey Station, who made a cross of the Black Mexican on the Egyptian. The resulting corn has not yet been selected long enough to be fixed in type, but it promises to be a valuable early corn.

The other corn I am breeding is a cross of my own of Country Gentleman on Giant. This is a later variety than Voorhees Red, but is greatly superior in quality. The fault of the Station sweet corn that I spent seven years in breeding was too shallow a grain and too large a cob. This is the fault of the Voorhees, but my corn takes from the Country Gentleman a very deep grain and a small cob, but not too small to hold 12 to 16 rows of grains. Several years more of selection will be needed to fix the character of either of these varieties of corn, but I feel that I now have a corn of great promise for the South.

The work with bulbs has been continued. Gladioli have done remarkably well and have increased enormously. Bermuda lilies were better than heretofore, but I believe that the lands of the coastal plain will be better suited to them. I was hoping, from the hundreds of dollars worth of bulbs I have sent there that something of value would be done, but I fear that the expense was in vain.

The greater part of my personal work has still been the correspondence with the farmers of the State. These letters are on file, but I have not attempted to count them, and have no numbering machine. It is enough to say that it takes the greater part of my time.

I attended and lectured at one series of Farmers institutes in July and August, but was not needed in the September series. At the special invitation of the farmers of Catawba County, I made a lecture to them at Newton on the 12th of October.

The Bureau of Plant Industry of the Department of Agriculture has taken great interest in my bulb experiments. They sent me last fall some fine bulbs of tulips which were grown in the State of Washington, and which they wished to have tested in the South. There were 150 of these. They were planted in October last in the strong and well-manured soil of my garden. When mature in the spring they were lifted, and I had 750 bulbs and offsets of all sizes. Mr. Oliver, a horticulturist, sent out by the Bureau of Plant Industry to

study the bulb-growing interest in North Carolina, visited me at the time my Bermuda lilies were in bloom, and took a photo of them showing the remarkable size of the flowers. Mr. Oliver was also surprised to note the great increase of the tulips, and took samples of the finest with him to Washington, being perfectly convinced that North Carolina can produce these bulbs on a commercial scale profitably.

He was also greatly interested in the remarkably fine bulbs I have grown of Sternbergia lutea and Nerine Sarniensis, and from his account on his return to Washington, the Bureau of Plant Industry asked me to make them a contribution of these bulbs for trial there, which request I of course complied with. These bulbs are planted in August and bloom in September and October before the leaves appear. The leaves then follow and remain green all winter. The Sternbergia is hardy North, but the Nerine will probably be cultivated only in pots north of Washington at least, and it remains to be seen whether they are hardy in Washington. There is a great deal of interest among the Northern dealers and horticulturists in the bulb-growing experiments I have been making here, and it is to be regretted that land and means can not be afforded me to carry on the work on a larger scale so as to demonstrate the best methods to use with these things. Millions of dollars worth of them are imported annually, and the dealers would be glad to know that they can be grown here. I feel that the North Carolina Station is neglecting a great opportunity to help the gardeners of the State to greater profit from these crops, and I believe that if the matter was properly presented to the Board of Agriculture, they would be willing to help the Station to get land suited to this work in the eastern part of the State. The Station should by all means continue this work even here, but the land I have is totally inadequate in area for the purpose of demonstrating the commercial side of the question, though I will be able to put quite a lot of bulbs on the market this winter of the spring-planted sorts. I believe that in the two lines of bulb culture and the propagation of roses for the Northern trade a place in the east could be made perfectly self-supporting, while giving the growers there an object lesson for them to follow. While as a rule I do not think that the Station should be required to earn money, if this can be done while demonstrating a great and profitable industry, it should be done. It ought not to cost a vast sum for the Station to acquire a small area of land and construct at least one small propagating house for this purpose.

There is still another variety of bulb that I am growing which has done remarkably well. This is the Amaryllis Johnsonii. These grow here to an immense size. Mr. Vaughn, a dealer in Chicago, paid me $20 per 100 for some, and 100 of the bulbs filled a flour bar-

rel. They are hardy here with a slight protection, but I lift them in the fall and pack them in a cellar so as to keep the roots alive during the winter and to get the offsets for increase. I am lifting this fall about 15,000 Gladioli bulbs or corms, all of which have been produced from 100 that I bought three years ago. A single square of my garden will produce easily $100 worth of these bulbs at the trade rates. I am also growing this year some cross fertilized seedlings of the Amaryllis. The work that has been done with these in California by Mr. Burbank has attracted universal attention from the enormous size of the flowers he has grown. There is no reason that I know of why mine should not turn out as well. I am hoping that some of them will bloom another summer. If I had greenhouse room to keep them growing during the winter I could easily bloom them in the spring.

Respectfully submitted,

W. F. Massey,
Horticulturist.

REPORT OF THE BIOLOGICAL DIVISION.

DIRECTOR B. W. KILGORE.

DEAR SIR:—During the past year an unusually large number of queries concerning the identity of various plant diseases have been received, owing probably to the fact that this year has been particularly favorable for the development of fungous pests. The cotton wilt and anthracnose, the apple rust, scab, and blight, the pear blight and scab, the wheat rust, the cabbage yellow-side, the cereal smuts, the melon anthracnose and wilt, the grape black rot, the brown mold of the drupaceous fruits, and the soft rot of the sweet potato, are the most prevalent and destructive diseases, and many inquiries concerning each were received.

An outbreak of the leaf blight of the celery, due to Cercospora, was especially destructive through the central portions of the State. The cotton anthracnose has been very destructive in certain localities. The fungus which causes this disease is under cultivation in the laboratory, and experiments with it are in progress in the green house.

The fungus *Ceratocystis,* causing the black rot of the sweet potato, has frequently been brought to our attention. Upon Brussel sprouts a *Phyllosticta* has been noted as causing serious disease in Wake County. Many maple trees were noticed with the leaves in a badly diseased condition, due to the presence of a *Septogloeum.* The old familiar *Cylindrosporium padi* has been very destructive to the cherry in Mecklenburg County. A species of *Septoria,* causing decayed spots upon the egg plant, has been repeatedly noticed. A form of anthracnose due to a *Colletotrichum,* has been found prevalent upon the pear, especially upon the riper fruits. This form does not seem to have been yet studied or described.

A leaf spot very prevalent upon the peanut, due to *Cercospora,* is of common occurrence, although this species does not seem to have been recorded previously in this State.

The *Septoria* of the tomato is abundant in many localities, and *Cercospora* was collected in abundance upon fig leaves, where it did much damage to the plant. This is probably *Cercospora bolleana,* which apparently has not been reported in North America, except from Alabama.

Frequent reports were received attesting the efficiency of the Bordeaux mixture in preventing the leaf spot of the apple, caused by a species of *Phyllosticta.* Numerous samples upon which the attacks of this pest had been checked, but upon which the rust had still been able to attain a foothold, have been received.

An outbreak of the lettuce disease, due to a fungus, *Botrytis,* in the

neighborhood of Fayetteville, was especially destructive. The disease was very closely studied and its cause ascertained definitely. The fungus isolated from the diseased plants and inoculated upon healthy plants in the green-house, caused the typical disease. This disease has been the subject of investigation in Massachusetts, where it prevails in green-houses. The conditions in North Carolina, where the lettuce is raised in the open or in cold frames, are fundamentally different. The disease is worthy of more complete investigation under North Carolina conditions. The following notes taken mainly by Mr. W. G. Sackett, are worthy of record.

"During the past eight years the lettuce growers in the vicinity of Wallace, N. C., have suffered heavy loss from a lettuce rot. The disease seems to have assumed a more aggravated form in the three years, 1901-1904, and in several cases the loss is estimated as high as 75 per cent. the average being about 50 per cent

The first sign of the disease is the rotting of the outer leaves lying next to the ground. The fungus attacks the large succulent midrib near the base of the leaf and spreads toward the tip, finally involving the blade. From these outer leaves the rot spreads rapidly through the base of the plant, so that in from six to ten days the head is rotted off close to the ground, while the greater part of the head appears to be perfectly sound. The youngest heart leaves are often a slimy, rotting mass. In some instances the disease becomes generalized and the whole head is simultaneously involved. All of the leaves drop flat on the ground and give the appearance of a severe case of frost bite; the leaves are more or less clear and transparent, and in a few days become a jelly-like mass of rotting lettuce, covered with a dense fungous growth.

The growers report the disease to be worse in wet weather, especially when accompanied by a warm spell followed by sudden cold. Many believe this change in weather to be the cause of the rot.

The rot does not seem to attack young plants, but is worse about two weeks before the heads are ready for the market. Lettuce grown on new land and in isolated fields seems to be no more free from the disease than that grown on soil formerly used for the same crop. It has been observed further that good, sturdy plants survive the disease much better than small sickly ones. In one instance plants taken from a seed bed which was made where a pile of wood ashes had accumulated during the winter did not die of the disease. Another bed which was made where hot water had been repeatedly thrown, produced plants that were not so susceptible to the rot as plants from adjacent beds. The meaning of this immunity of plants from particular seed beds is not yet clear."

The Granville tobacco wilt, described by this Station in Bulletin 188, last year, has spread to several regions uninfected last year, the

spread being slow, though certain in every direction from the regions already infected. The disease has also appeared upon a portion of the College farm, which was devoted to a study of this disease last year. Various attempts at inoculation were made in this field. Diseased plants and soil from the affected Granville County land were brought to it, and the bacteria suspected of causing the disease were placed in large quantity in the soil. A crop of tobacco raised upon this soil this year for the purpose of determining whether infection of the soil had been secured, presented many typical cases of the Granville tobacco wilt, thus demonstrating beyond question the communicability of the disease from field to field. Further investigations looking toward a more accurate determination of the cause of this disease have been impossible, owing to the lack of time and equipment. Some work has been done, however, near Creedmore, experimenting with various kinds of soil treatment. Some of the chemicals employed have lessened very materially the amount of wilt, though none are sufficiently effective to warrant their recommendation. This work will be continued next year. Many varieties of tobacco have been grown upon infected fields with the hope of finding some variety that will resist the wilt. Some varieties show much more resistance than others, but this work has not yet progressed far enough to allow of a definite report.

The Biologist has co-operated with the Bureau of Plant Industry of the Department of Agriculture at Washington in an effort to secure, by breeding, a variety of watermelon which will be capable of resisting the wilt. The results of this work so far are very promising, and the work will be continued another year.

The work of previous years concerning the dissemination of knowledge of means for preventing the oat and other cereal smuts by the formalin method has been continued through this year. More than one hundred farmers, widely scattered throughout the State, have become familiar with the method and the efficiency of the treatment for the prevention of smut.

Nature study is recognized as a factor in promoting the interest in progressive agriculture. Many of the Experiment Stations are devoting much energy to the advancement of interest in Nature Study. Much work of this kind has been done by the Biologist during the past year. While this is done independently of his Station duties, it should still be mentioned in connection with them. During the past year a bulletin for use in the common schools has been prepared, also a graded course of Nature Study for the schools; and numerous articles for teachers in the *Progressive Farmer* and in various teachers' journals. A State Nature Study Society, with a large membership and a conspicuous activity, has been organized for the promotion of Nature Study.

Respectfully submitted,

F. L. Stevens, *Biologist.*

REPORT OF POULTRY DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1904.

The new buildings have all been completed and the necessary equipment provided, and such of the old buildings as were suitable have been moved to the new location, a few changes being made in them to make them better adapted for winter quarters.

The past winter was unusually severe, and gave us a good chance to test our new buildings, and I was greatly pleased with the results, from the "Scratching Shed House." The fowls coming through the winter in good condition and laying well during the worst weather; in fact, laying did not seem to be affected to any appreciable degree by the weather, as we were able to keep the fowls comfortable at all times.

The new incubator cellar was also of great value during the cold weather, for while the temporary quarters used last year gave fairly satisfactory results during the mild weather, it would have been almost impossible to use them during the past winter. Being entirely above ground, the variation in temperature was too great and too sudden to make successful work possible.

Experiments with egg preservatives were conducted, ten different methods being tested, five being liquid preparations and five dry methods. The results of this work will be published during the coming winter in a bulletin.

Some of the feeding work planned could not be carried out, owing to our inability to get skim milk, but a supply of this has now been arranged for and the experiments will go on this year as outlined in my last report.

Some crate feeding was done, and is being continued this year, and the results will be published later.

Records have been kept of the eggs laid by the different breeds, and this year I expect to use some trap nests, so that I will be able to select only the best layers for next season's breeders.

The correspondence has increased very rapidly, and shows an increasing desire on the part of the farmers of the State for information regarding poultry matters.

Acting under your instructions, I became a member of the State Poultry Association, and at their annual meeting was made secretary of the Association, which will considerably increase the amount of correspondence which I have to attend to.

At the request of two of the Poultry Associations of the State, we made exhibits of our fowls at their exhibitions in December and

January, our birds winning well in all classes. These exhibits no doubt helped the sale of eggs for hatching, and the demand was greater than we could supply.

All surplus stock was sold at fair prices, our object being more to get good stock distributed through the State than to make a profit on the birds sold.

I was called on to do some judging during the fall, and from inquiries at hand at present I think this work is likely to grow and take up more of my time in the future as I become better acquainted with the poultrymen of the State.

We have in our breeding pens at present nine different varieties of fowls, as follows: Barred and White Plymouth Rocks, White and Buff Wyandottes, Light Brahmas, Buff Orpengtons, White and Brown Leghorns and Black Minorcas. These varieties cover the field of the utility breeds fairly well, and while there are many more good breeds and good varieties of some of the breeds named, those we have are the ones most generally kept.

Respectfully submitted,

J. S. Jeffrey,
Poultryman.

REPORT OF DIVISION OF ENTOMOLOGY.

MR. B. W. KILGORE, *Director.*

SIR:—The following report covers the operations of the Entomological Division of the Experiment Station for the past year. As has been pointed out in previous reports, the main work of your Entomologist is conducted under the Agriclutural Department and is more fully set forth in the reports to the Board of Agriculture.

All correspondence pertaining to insects and insect pests which has been addressed to the Station has been referred to me, and has had my careful attention. While it is not possible to state just how much of the office correspondence was in regard to letters sent to the Station, it may be said that in all, this office has sent out, between January 15, 1904, and October 1, 1904, one thousand three hundred and sixty written signed letters, besides a number of circular inquiries.

In the field work the Station orchard has been our main place of operations in the Station work. The peach trees were all wormed in late winter and earth banked at the base to prevent laying of eggs by the adult moths. Frames were made for collecting Curculios from the trees, and were operated until it became evident that the number of curculios was not sufficient to warrant a continuation of the process. The peach and plum orchards were sprayed three times with the Bordeaux mixture, a considerable part of the work being done by your Entomologist in person and the greater portion being done by Mr. R. W. Collett, of Andrews, N. C., who assisted in the work of this office from March 20 to July 6. The peach trees set, and brought through the season, a very good crop of fruit, reasonably free from Curculio and Brown rot. One or two of the earliest varieties rotted quite badly, there being in the case of some trees no noticeable difference between those sprayed and not sprayed. The land upon which these peach trees stand has been poorly cultivated and fertilized, being sadly in need of both plant food and humus. For this reason, although there was a prospect for a fair crop of fruit this year for the first time in the history of the orchard, yet the trees could not bring the fruits to maturity and they remained on the trees tasteless, insipid and poorly colored.

The San Jose scale has been in this orchard for several years. The colony of Chinese lady-beetles which was liberated over a year ago seems to have entirely disappeared, and this winter the orchard will be treated with the lime-sulphur-salt wash.

The plum trees bore a good crop, and rotted much less than has been the case in years when no spraying was done.

The work this summer was very satisfactory, as evidence of the possible control of the Brown rot, for just as the ripening season began

a warm rainy spell set in which could not have been more favorable to the development of the fungus.

The tests and observations of the Brown rot were made after consultation with the Botanist.

Respectfully submitted,

FRANKLIN SHERMAN, JR.,
Entomologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION, 1903,—1904.

DR.

To receipts from the Treasurer of the United States as per appropriation for the fiscal year ending June 30, 1904, as per act of Congress approved March 2, 1887.....$15,000.00

CR.

By Salaries	$9,850.00
Labor	1,709.13
Publications	2,254.29
Postage and stationery	374.60
Freight and express	197.87
Heat, light, and water	57.61
Chemical supplies	63.05
Seeds, plants and sundry supplies	0.00
Fertilizers	115.49
Feeding stuffs	0.00
Library	46.06
Tools, implements, and machinery	70.65
Furniture and fixtures	0.00
Scientific apparatus	7.50
Live stock	0.00
Traveling expenses	238.75
Contingent expenses	15.00
Buildings and repairs	0.00
Total	$15,000.00

We, the undersigned, duly appointed auditors of the Corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1904; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

(Signed)

S. L. PATTERSON,
B. W. KILGORE,
Auditors.

(Seal).

Attest: A. F. BOWEN,
Custodian.

(Contribution from the Chemical Division—W. A. Withers, A.M., Chemist.)

THE AVAILABILITY OF POTASH AND PHOSPHORIC ACID IN SOIL.

G. S. FRAPS, Ph.D., Assistant Chemist.

This is a scientific article, which has for its object the study of the different influences which act to release the plant food locked up in the soil.

The most important results are two. First, facts are accumulated which show that locked-up plant food becomes available, little by little, under ordinary conditions in the field. Second, evidence is afforded that decaying vegetable matter aids greatly in this change in the case of potash; which helps to explain why barn-yard manure is so lasting in its effect, cases being known in which the beneficial action of the manure continued 20 to 40 years.

The article also includes a discussion of available plant food, and the changes in the vegetable matter or humus in the soil.

The growing plant removes from the soil certain elements in different forms of combination, most of which are absolutely necessary for its growth and fruition. It is generally believed that the crop which can be produced upon any given field depends, certainly to a large extent, on the amount of plant food accessible to the plant. The different elements which are necessary to plant life exist in the soil in a great number of forms of combination, some of which can be taken up by plants, while others can not. From 200 to over 10,000 pounds of potash may be found in an acre of soil, only a small part of which is available at a given time. The term *available* has been used, somewhat loosely, to indicate the amount of plant food accessible to plants. This term needs a precise definition, for, as will be shown later, there are a number of factors involved in the term as loosely used. Soils with a sufficient supply of all necessary elements in an available form will produce good crops without fertilization, provided other conditions are favorable, while soils which are deficient in one or more elements in available forms either require fertilization, or such treatment as will convert unavailable compounds into available ones. The elements potassium, nitrogen, and phosphorus are the ones which fail most often to be present in sufficient quantity as available compounds.

FACTORS OF AVAILABILITY.

Any judgment as to available plant food is referred finally, if not at first, to the crop-producing power of the soil. Thus a soil is said to be deficient in available phosphoric acid if fertilization with phosphoric acid increases the yield of the crop largely. If the addition of potash produces much better crops, it is said to be deficient in available potash, and deficiency in nitrogen is judged in the same way.

Numerous attempts have been made to determine, by chemical methods, the requirements of soils for fertilizers—that is, whether the soil needs phosphoric acid, potash, lime, etc.; but there is still no successful method. The object has been to obtain a solvent which would exert the same solvent action upon the soil as the plant does. The relation of the plant to the soil is a complex one, and the amount of plant food removed from the soil by a given crop depends upon a number of circumstances. In other words, "availability," as determined by field work, may be split up into a number of factors, each one of importance. The conditions of moisture and temperature, aside from the presence of plant food, are of profound influence upon the growth of the crop. Without considering these, the amount of plant food taken from the soil by a plant depends on the following "factors of availability."

(1) *Chemical Availability.*—The amount of plant food present in the soil at the beginning of the growing season in forms of combination which can be directly taken up by the plant, is one factor of availability, which will be called the chemical availability.

(2) *Physical Availability.*—Certain portions of the soil constituents may be in such chemical combinations as are absorbed by the plant, but in such a form of physical aggregation as to be withheld from it. They may be so protected or enclosed by soil particles as not to be exposed to the action of plant roots.

(3) *Weathering Availability.*—It is recognized that the compounds in soils are undergoing chemical changes by the action of weathering, by which the insoluble complex compounds are gradually broken down into more soluble, simple compounds.

Thus the total amount of plant food accessible to the plant is equal to that accessible at the beginning of the growing season, plus that transformed during the season. It is possible that this addition may be so slight as to be disregarded in some cases, in other cases it may be of tremendous importance. For example, a soil may contain only a small quantity of available nitrogen at the beginning of the growing season, but the action of the nitrifying organisms and other bacteria may transform a sufficient quantity during the growth of the plant to more than satisfy its needs.

(4) *Physiological Availability.*—Plants differ in their feeding power, and a compound which may be absorbed directly by one plant, may not be absorbable by another. We will call this *physiological availability.*

The solution of any problem involves the consideration of all the factors embraced in it, and their valuation. It is not surprising that a consideration of any one of the factors alone should not lead to satisfactory conclusions.

These factors require some discussion, and they will be discussed in the following sections.

CHEMICAL AVAILIBILITY OF PLANT FOOD.

As has been stated, for want of a better term, the plant food in the soil in such forms as can be absorbed by plants, is called *chemically available.* The fact that some compounds are readily taken up by plants, while others are not, requires little discussion, as it is well known. As an example is given the relative effect of different phosphates on winter barley (Kellner, Versuchstationen *43* (1894), 1:

Superphosphate	100
Raw bones	56
Thomas slag	55
Bone ash	21

How much of the difference in action is due to difference in weathering of the different materials can not be judged.

PHYSICAL AVAILABILITY.

In this case, the effect of the mechanical aggregation of the soil particles must be considered. It is obvious that, however soluble the plant food may be, it is not available to the plant if it is enclosed and protected from the action of the roots. It is difficult at present to form any judgment as to the importance of this factor.

THE NATURE OF THE PLANT.

This factor has not been studied as thoroughly as it might have been, and comparatively few quantitative data are available.

Dietrich (Jahresbericht Agr. Chem. 1863 1) grew plants in new red sandstone and basalt which had been previously extracted with water to remover water-soluble constituents.

The amount of mineral matter dissolved by one per cent nitric acid in each pot, plus the ash of the plants, and minus the ash of the seeds, and the soluble mineral matter in a pot in which no seed had been planted, gives the weathering effect of the plants:

TABLE I.—MINERAL MATTER MADE AVAILABLE BY PLANTS.

Number of Plants.	Kind.	Sand-stone Grows	Basalt Grows
3	Lupine	0.6080	.7492
3	Peas	.4807	.7132
4	Vetch	.2212	.2514
8	Wheat	.0272	.1958
8	Rye	.0137	.1316

There is thus a great difference between the power of different plants to decompose the sandstone and basalt. Wheat and rye are particularly weak in solvent power.

Kassovich [Experiment Station Record *13*, 265 (Abstract)] divides plants into four groups in regard to their ability to utilize the phosphoric acid of phosphates. (1) Plants with high capacity; mustard, buckwheat, hemp, and winter rye. (2) Plants with medium capacity; peas, barley, summer rye, beets. (3) Plants with low capacity; potatoes, oats, vetches. (4) Plants almost devoid of capacity; millet, flax, clover.

Prianishnikov [Experiment Station Record *13*, 934 (abstract)] in pot experiments found that the cereals in general (millet, rye, wheat, etc.) showed a very limited capacity for assimilating crude phosphates. Buckwheat, lupines, peas, and mustard utilized them to a greater extent.

WEATHERING AVAILABILITY.

By "weathering availability" is meant the amount of plant food which is converted into forms assimilable by plants during the growing season. In the case of nitrogen, this factor is certainly of great importance. Changes are continually taking place in cultivated soils, which convert inert nitrogenous compounds into available forms, particularly nitrates. The amount of nitrates in a soil at a given time is no indication as to the amount of nitrogen available to the plant, since the quantity which may be produced is unknown. A soil may contain a small amount of nitrates, and yet the activity of chemical changes be such that sufficient nitrogen is afforded the plant to more than satisfy its needs. On the other hand, the transformation of the inert nitrogen may take place very slowly.

In regard to the weathering of the other elements, comparatively little work has been done.

Th. Schloesing fils (Compt. rendu. June 9, 1902) determined the phosphoric acid extracted by seven treatments with water from dry soil, and the same soil which had been kept moist for four months.

TABLE II.—WATER-SOLUBLE PHOSPHORIC ACID

Soil.	Parts Per Million.		
	Dry.	Wet.	Gain.
Galande	10.0	11.2	1.2
Neauphle	36.9	40.4	3.5
Joinville	47.0	53.8	6.8
Boulogne	104.4	126.7	22.3

There is thus a gain of from 1.2 to 22.3 parts of water-soluble phosphoric acid per million, or on the basis of three million pounds soil per acre, from 3.6 to 66.9 pounds.

Schloesing (ibid, Jan. 6, 1902) also determined the amount of water-soluble phosphoric acid removed by corn. The phosphoric acid was determined in samples of the soil taken before and after growing the corn by extraction ten times with water, with the following results:

TABLE III.—PHOSPHORIC ACID ASSIMILATED.

Treatment.	Parts Per Million.	
	Boulogne Soil.	Galande Soil.
Water-soluble before growing corn	150.2	14.3
Water-soluble after	122.1	8.6
Loss (parts per million)	28.1	5.3
	Grams.	
Loss in 36 Kgr. soil (grams)	1.012	0.199
Found in corn	1.115	0.451
Difference	0.103	0.252

It is evident that in one case the corn drew most of its phosphoric acid from water-soluble compounds, while in the other case it took up more not soluble in water.

Stoklasa [Versuchstationen *37* (1890) 66] made some experiments on the weathering of soils. The results here given are only for potash and phosphoric acid. The soils were weathered one year, being cultivated.

TABLE IV.—WEATHERING OF SOILS.

Nature of Soil.	Soluble in 20 % Acetic Acid.		Soluble in Hydrochloric Acid.	
	Potash.	Phosphoric Acid.	Potash.	Phosphoric Acid.
	Per cent	*Per Cent.*	*Per cent.*	*Per cent.*
Sandy soil, weathered	.021	.009	.073	.081
Original soil	.009	.004	.075	.084
Gain	.012	.005	—.002	—.003
Lime soil, weathered	.086	.024	.146	.032
Original soil	.059	.019	.130	.035
Gain	.027	.005	.016	—.003
Clay soil, weathered	.081	.....	.268	trace.
Original soil	.099	.....	.154	trace.
Gain	—.018	.....	.114	.....

It is evident, from the work cited, that the weathering factor is one that cannot be neglected entirely in considering the available plant food in soils.

FACTORS OF WEATHERING.

Weathering is in itself of complex nature, and is dependent upon a number of factors. Some of these are discussed in the next paragraphs. It may be well to state that these factors have been worked out most satisfactorily with nitrogen, hardly at all with the other elements.

(1) *Form of combination of the elements.* Different compounds are converted into more soluble compounds with different degrees of rapidity. For examples, different nitrogenous compounds are nitrified, under the same conditions, as follows:

TABLE V.—NITRIFICATION OF FERTILIZERS.*

In soil (1900).	Per cent.	Rank.
Cottonseed meal	54.8	100
Dried blood	54.9	100
Ammonium sulphate	31.1	55
Fish	46.5	85
Bone	16.6	30

(2) *Nature of the soil.* By this, we mean the physical and chemical character of the soil taken together. This factor may be split up into a number of others, the effect of different compounds in the soil being studied.

As an example of the effect of the nature of the soil, the relative

*See preceding article on Nitrification of Different Fertilizers. (Report 1902-3.)

amounts of nitrates produced under the same conditions in different soils is given.†

TABLE VI.—NITRIFYING POWERS OF SOILS.

Soil.	Rank.
Standard soil	100
Tarboro sand	16
Norfolk sand	18
Porter's loam	85

(3) *Moisture, temperature,* the presence or absence of organic matter, etc., are other important factors in weathering.

REVERSE WEATHERING.

Besides the direct decomposition of insoluble compounds with the production of more soluble ones, a reverse action may take place, in which the plant food is rendered more insoluble. This action is of considerable importance when fertilizers are added to the soil, when it is known as fixation. As examples may be given the fixation of potash by zeolites or otherwise, and the conversion of soluble calcium phosphate into insoluble compounds. There is also a further transformation of phosphates, by which calcium phosphate is changed to the very insoluble ferric phosphates and aluminium phosphates.

EXPERIMENTAL PART—STUDY OF THE CHANGES CAUSED BY WEATHERING

The object of this work was to determine the amount of potash and phosphoric acid transformed into more available forms under the influence of moisture, organic matter, calcium carbonate and calcium sulphate. Incidentally some study of the organic matter and the changes in humus was made on certain of the samples, though this was not originally contemplated in the investigation.

The potash and phosphoric acid were determined by fifth-normal nitric acid, and in some cases, by fiftieth normal acid. The compounds dissolved by these solvents are not supposed to be directly assimilable by all plants, and the method can be considered to give only comparative results. It at least would show the transformation of the less soluble into more soluble forms of combination. Had time permitted, other solvents would have been used in addition.

PLAN OF WORK.

The soils used are described below. The samples were mixed with water, and the other additions as described in the table below.

† See preceding article on Nitrification in Typical Soils. (Report 1902-3.)

TABLE VII.—ADDITIONS TO SOIL.

Sample No.	Water, cc.	Other Additions.
1	385	O
3	385	25 gm. calcium carbonate.
5	385	25 gm. calcium sulphate.
7— 8	435	200 gm. starch.
9—10	435	200 gm. pine saw-dust.
11	dry	O
13	dry	50 gm. calcium carbonate.
15	dry	50 gm. calcium sulphate.

For furnishing the organic matter, materials were chosen which would contain as small quantities of phosphoric acid and potash as possible. Pine sawdust, and starch, while perhaps not so suitable from other standpoints, were selected for this reason.

The soil, water, and other additions, were mixed in a porcelain evaporating dish, transferred to glass or earthenware jars, and kept moist for four months by the addition every two weeks of water sufficient to restore the loss by evaporation. The samples then rested for a month and a half longer, when they were dried, and smaller samples taken for analysis. Except the samples to which starch and sawdust had been added, all of the samples were dry at that time. Portions of the two latter samples had been removed for analysis at two previous periods, as stated in the section on humus.

The soil was inoculated with germs in each case; 50 grams of a nitrifying soil were mixed with 500 cc. water, allowed to settle, and 10cc. mixed with the water used to moisten the soil in the first instance.

DESCRIPTION OF SOILS.

1786. Sandy soil from the Red Springs State farm of the N. C. Department of Agriculture, furnished through the courtesy of Prof. B. W. Kilgore, State Chemist.

1787. Cecil sandy loam from farm of A. and M. College at Raleigh, near railroad crossing. A good soil.

1788. Durham sandy loam from College farm. "So poor it will not grow cowpeas."

The relative nitrifying powers of these soils are as follows:

1786.	Red Springs sand	71
1787.	Cecil sandy loam	100
1788.	Durham sandy loam	14

This data was taken from the preceding article on the nitrifying properties of typical North Carolina soils, and other data in regard to these soils may be found in that article.

METHODS OF ANALYSIS.

Potash and phosphoric acid are determined with N/5 nitric acid, the procedure being the same as described for N/5 hydrochlorine acid in the Methods of the Association of Official Agricultural Chemists. Twenty grams of soil were first digested with 200 cc. N/5 nitric acid at 40 degrees; shaking every half hour, and at the end of five hours, the liquid was filtered off and titrated with caustic soda and phenolphthalein. With the exception of the samples to which calcium carbonate had been added, the soils were practically neutral. Two hundred grams of soil were digested as before with 2 liters N/5 nitric acid, (corrected, when necessary, for the acid neutralized by the soil,) filtered through a double filter, and 1700 cc. (=170 grams soil) taken from the determination of potash or of phosphoric acid as the case might be.

For potash, the 1700 cc. was evaporated in a porcelain dish, transferred to a platinum dish and evaporated to dryness with the addition of a little sulphuric acid. After ignition, the residue was taken up with hot water, filtered, acidified, evaporated with the addition of platinum chloride, and the determination completed in the usual way. If the residue is taken up with hot water and hydrochloric acid after ignition, the filtrate contains a large quantity of salts which are difficult to remove with the ammonium chloride wash, but no difficulty is experienced if hot water alone is used.

The determination of potash with N/50 nitric acid were made in a similar way.

Phosphoric acid and humus were determined as described in the Methods of the Association of Official Agricultural Chemists.

Moisture was determined by drying five grams of the sample five hours, in a water oven. The residue was then ignited, and the residue constitutes what is termed the *ignition residue*. The loss on ignition consists of organic matter and water.

WATER AND ORGANIC MATTER.

With the exception of samples 7 and 9, to which organic matter had been added, the *ignition* residue was sufficiently constant to allow a direct comparison of the results. In the two cases mentioned, the amount of potash and phosphoric acid was corrected, being calculated to the same amount of ignition residue as in the other samples.

As an example of the method of calculation, the following is given:

The average percentage of ignition residue in the samples of soil 1786 (excepting Nos. 7 and 9) was 98.4 per cent. Sample 9 contained 93.3 per cent ignition residue, and .1587 grams potassium platinum chloride was obtained from 170 grams of it. Then $\frac{.1587 \times 98.4}{93.3}$ would be the weight of precipitate if the soil contained

98.4 per cent of ignition residue. Corrections were made in a similar way on the other samples.

Potash was also corrected for the potash in the sawdust and starch. The method will be described later.

The percentages of water and loss on ignition in the soil are presented in Table VIII.

TABLE VIII.—WATER AND LOSS ON IGNITION.

Soil No.	Sample No.	Water.	Loss on Ignition.	Total.
		Per cent.	*Per cent.*	*Per cent.*
1786	1	0.24	1.31	1.55
	3	.22	1.46	1.68
	5	.22	1.32	1.54
	11	.22	1.38	1.60
	13	.22	1.49	1.71
	15	.23	1.48	1.71
Average				1.65
	7	.40	3.22	3.62
		.40	3.20	3.60
	9	.41	6.71	7.18
1787	1	.72	5.48	6.20
	3	.66	4.04	4.70
	5			4.91
	11			4.76
	13			4.65
	15			4 65
Average				4.73
	7	1.29	4.60	5.89
		1.27	4.18	5.45
	9	1.08	8.44	9.52
		1.21	8.81	10.02
1788	1	0.38	1.31	1.69
	3			1.74
	5			1.55
	13			1.49
	15			1.79
Average				1.61
	7	.57	2.36	2.93
		.57	2.20	2.77
	9	.66	5.10	5.76
		.86	4.74	5.60

RESULTS OF WORK.

The percentages of potash and phosphoric acid found in the different samples (corrected where necessary) are presented in Table IX.

In the cases in which the dry soil was used, alone or mixed with calcium salts, it was not to be supposed that any reaction would

take place in the dry soil. These samples were used for purposes of comparison only. It was thought possible that when the soil came to be extracted with acid, the presence of calcium salts would have some effect upon the amount of potash or phosphoric acid, and indeed, this was found to be the case. The calcium salts, therefore, were not considered to have any effect on the dry soil itself, but on the solvent effect of the acid.

TABLE IX.—PERCENTAGE OF PHOSPHORIC ACID (P) AND POTASH (K).

Sample Number.	Treatment.	Soil 1786.		Soil 1787.			Soil 1788.		
		P	K	P	K	K^{N}_{50}	P	K	K^{N}_{50}
1	Moist		.0041	.0070	.0111	.0054	.0075	.0080	.0072
3	Moist with $CaCO_3$	.0034	.0036	.0078	.0074	.0035	.0067	.0068	.0048
5	Moist with $CaSO_4$	.0061	.0058	.0114	.0095	.0039	.0081	.0061	.0058
7	Moist with starch	.0039	.0053	.0059	.0154	.0076	.0060	.0153	.0084
9	Moist with sawdust	.0041	.0044	.0072	.0146	.0057	.0053	.0165	.0076
11	Dry	.0047	.0035	.0077	.0098	.0061	.0063	0090	.0072
13	Dry with $CaCO_3$	.0041	.0033	.0090	.0073	.0055	.0066	.0088	.0045
15	Dry with $CaSO_4$	.0045	.0032	.0112	.0080	.0056	.0073	.0061	.0057

RELATIVE SOLVENT POWERS OF N/5 AND N/50 NITRIC ACID.

The relative power of N/5 and N/50 nitric acid to dissolve potash is illustrated in Table IX. The N/50 acid dissolves from 40 to 80 per cent as much potash as N/5 acid from soil 1787, and from 50 to 90 per cent from soil 1788. The average for soil 1787 is about 55 per cent and for soil 1788, 75 per cent. The potash in soil 1788 is relatively more easily soluble than in 1787.

It might be expected that the ratio of the quantities of potash dissolved by the two solvents would be constant. Since the agencies at work, however, are active on all the compounds in the soil, and are different in the different samples, it is not surprising that in some cases more soluble compounds should be affected, and in other cases, less soluble ones, to a greater extent.

EFFECT OF MOISTURE.

By subtracting the amounts of potash and phosphoric acid in certain samples from those in others, it is possible to estimate the different factors involved in this case. It must be remembered that in some cases these figures are not directly comparable. For example, the difference between the N/5 soluble potash or phosphoric acid in a moist soil containing calcium carbonate, and in a dry soil containing calcium carbonate does not really represent the action of

moisture alone. Agreement between the three series of results in the table need not, therefore, be expected.

The value of the work is somewhat lowered because it was not done in duplicate, but nevertheless, results of importance have been developed.

The effect of moisture is shown in Table X.

TABLE X.—EFFECT OF MOISTURE ON PHOSPHORIC ACID (P) AND POTASH (K).

Sample Number.	Treatment.	1786		1787			1788		
		P	K	P	K	K^{N}_{50}	P	K	K^{N}_{50}
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	Moist	. . . .	.0041	.0070	.0111	.0054	.0075	.0080	.0072
11	Dry	.0047	.0035	.0077	.0098	.0061	.0063	.0090	.0072
	Gain (+) or loss(—)	?	+.0006	—.0007	+.0013	—.0007	+.0012	—.0010	0
3	Calcium Carbonate, moist . . .	.0034	.0036	.0078	.0074	.0035	.0067	.0068	.0048
13	Calcium carbonate, dry . . .	.0041	.0033	.0090	.0073	.0055	.0066	.0088	.0045
	Gain (+) or loss (—) . . .	—.0007	+.0003	—.0012	+.0001	—.0020	+.0001	—.0020	+.0003
5	Calcium sulphate, moist . . .	.0061	.0058	.0114	.0095	.0039	.0081	.0061	.0058
15	Calcium sulphate, dry . . .	.0045	.0032	.0112	.0080	.0056	.0073	.0061	.0057
	Gain (+) or loss (—) . .	+.0016	+.0026	+.0002	+.0015	—.0017	+.0008	+.0000	+.0001
	Average gain (+) or loss (—)	+.0005	+.0012	—.0006	+.0010	—.0015	+.0001	—.0010	+.0001

Phosphoric Acid.—There has been a slight average gain of phosphoric acid soluble in N/5 acid. Moisture alone causes a 10 per cent decrease of phosphoric acid in one case, a 20 per cent increase in another, (the third lost); moisture and calcium carbonate compared with calcium carbonate, a decrease (13 to 16 per cent) in two cases, no change in the third; moisture and calcium sulphate compared with calcium sulphate, an increase in each case (35, 2 and 11 per cent respectively), which is particularly large in soil 1786 (35 per cent).

The effect of calcium sulphate in the dry soil has also been to increase the amount of phosphoric acid dissolved by N/5 nitric acid, although there is a slight decrease in one case. The change is caused either by the increased solvent action of the nitric acid in the presence of the calcium salts, or by the action of the calcium salts on the phosphoric acid of the soil during the time of action of the acid. This effect increases when the moist soil is allowed to stand four months. The fact mentioned can not but be of importance.

The decrease in the solubility of phosphoric acid where it occurs may be due to its gradual conversion from calcium phosphates to iron or aluminium phosphates. This is a case of reverse weathering, already referred to. In the presence of calcium sulphate, there seems to be a gradual change in the other direction—indeed, the change takes place almost at once, in part.

Potash.—There has been an average gain of potash soluble in N/5 nitric acid, and an average loss of potash soluble in N/50 acid, due to the addition of moisture. The average gain in the soils in N/5 soluble potash is 10 per cent for each. The following discussion refers only to N/5 acid.

Moisture alone causes a decrease of potash in one case (11 per cent), and an increase in two cases (16 and 13 per cent); moisture and calcium carbonate compared with calcium carbonate, a slight increase in two cases, a decided decrease in one; moisture and calcium sulphate compared with calcium sulphate, a decided increase in two cases (80 and 19 per cent), and no change in the third.

In soils 1786 and 1787, moisture gave an increase in soluble potash in each case, though the increase is slight in two instances, while the soluble potash in soil 1788 shows a tendency to decrease. There is thus a decided difference between the three soils. On the whole, the effect of moisture, alone or in presence of calcium sulphate, may be said to increase the N/5 nitric acid soluble potash. Moist calcium carbonate retards the action of moisture alone, as may be seen by comparing the first and second series of results, and it thus has a tendency to decrease the weathering. In every case, less potash is changed by moisture and calcium carbonate than by moisture alone.

In regard to the potash soluble in N/50 acid there has been a loss in each case with soil 1787, and practically no change with soil 1788 from the addition of moisture. The cause of the loss with soil 1787 is hard to say, particularly as there is a gain of potash soluble in N/5 acid. It is possible that complex silicates are formed, which are insoluble in the weaker acid, but soluble in the stronger.

Difference in the Soils.—The difference in the soils is most marked. The potash in the poor soil, 1788, is little susceptible of increase in solubility, and some explanation of its poor quality may be found in this fact.

EFFECT OF CALCIUM COMPOUNDS.

Again we must remark that the amount of potash found in the moist soil with calcium carbonate, less the amount in the moist soil alone, does not necessarily represent the effect of calcium carbonate alone, and we can not expect an agreement between the different series of results.

The results are presented in Table XI.

In considering Table IX, it must be remembered, as has been stated before, that no reaction is supposed to take place between the calcium carbonate or calcium sulphate and the dry soil. The difference in the results is due either to the change in the solvent power of the nitric acid in the presence of calcium salts, or to the action of the calcium salts upon the soil during the time of digestion with the dilute nitric acid. At any rate, the presence of the calcium salts in the dry soil has caused a difference, and it was necessary, for the purpose of comparison, to determine its extent. In the discussion which follows, it is assumed that the difference is due to the action of the calcium sulphate upon the soil itself, a view very probable. If the calcium salts affected the solvent power of the acid, the results should all be uniformly in the same direction with all the soils, which is not the case.

TABLE XI.—EFFECT OF CALCIUM COMPOUNDS ON PHOSPHORIC ACID (P) AND POTASH (K).

Sample Number.	Treatment.	1786		1787			1788		
		P	K	P	K	K^{N}_{50}	P	K	K^{N}_{50}
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
13	Calcium carbonate, dry . . .	.0041	.0033	.0090	.0073	.0055	.0066	.0088	.0045
11	Dry	.0047	.0035	.0077	.0098	.0061	.0063	.0090	.0072
	Gain (+) or loss (—) . .	—.0006	—.0002	+.0013	—.0025	—.0006	+.0003	—.0002	—.0027
3	Calcium carbonate, moist . .	.0034	.0036	.0078	.0074	.0035	.0067	.0068	.0048
1	Moist	.0047*	.0041	.0070	.0111	.0054	.0075	.0080	.0072
	Gain (+) or loss (—) . .	—.0013	—.0005	+.0008	—.0037	—.0019	—.0008	—.0012	—.0024
	Average gain (+) or loss (—)	—.0010	—.0003	+.0011	—.0031	—.0013	—.0003	—.0007	—.0026
15	Calcium sulphate, dry . . .	.0045	.0032	.0112	.0080	.0056	.0073	.0061	.0057
11	Dry	.0047	.0035	.0077	.0098	.0061	.0063	.0090	.0072
	Gain(+) or loss (—) . .	—.0002	—.0003	+.0035	—.0018	—.0005	+.0010	—.0029	—.0015
5	Calcium sulphate, moist . .	.0061	.0058	.0114	.0095	.0039	.0081	.0061	.0058
1	Moist	.0047*	.0041	.0070	.0111	.0054	.0075	.0080	.0072
	Gain (+) or loss (—) . .	+.0014	+.0017	+.0044	—.0016	—.0015	+.0006	—.0019	—.0014
	Average gain (—) or loss (—)	+.0006	+.0007	+.0040	—.0017	—.0010	+.0008	—.0024	—.0015

* Dry.

Phosphoric Acid.—The effect of calcium carbonate has been to decrease the amount of N/5 soluble phosphoric acid in two of the soils 20 and 4 per cent, and increase it in one soil 14 per cent. Where there is a decrease of phosphoric acid, the decrease is larger in the moist soil with calcium carbonate, and in the case in which there is an increase, this increase is less in the moist soil than in the dry soil. In other words, the general effect of moist calcium carbonate is to reduce the solubility of the phosphoric acid over the dry soil with calcium carbonate. In soil 1787 calcium carbonate renders a decidedly larger amount of phosphoric acid soluble in N/5 acid.

The average effect of the calcium sulphate is to increase the amount of phosphoric acid soluble in N/5 nitric acid. In only one instance is there a decrease, and this is so slight as to be practically none. A very decided increase (53 per cent) takes place with soil 1787. This is the soil on which the calcium carbonate was effective; calcium sulphate makes four times as large a gain as calcium carbonate did. On the other soils, a loss of soluble phosphoric acid with calcium carbonate is converted into a gain with calcium sulphate.

The great increase in the solubility of phosphoric acid in soil 1787 when calcium sulphate is added to the wet or dry soil, is worthy of emphasis. The average increase in this soil is over fifty per cent. In making the analyses of these samples, it was observed that the solutions were a much darker yellowish-brown than the others, probably from the presence of more iron salts. Possibly the presence of calcium sulphate causes the solution of ferric phosphate, along with other iron salts.

Potash.—The results for potash tend in the same direction, whether N/5 or N/50 nitric acid was the solvent, and the results are remarkably uniform in the same direction.

Calcium carbonate causes a decrease in the solubility of potash in every case, wet or dry. The decrease with N/5 acid is greatest with soil 1787, and with N/50 acid is greatest with the poor soil, 1788.

Calcium sulphate also causes a decrease in the solubility of potash. In only one instance (soil 1786) is there an increase, though in this case the increase is considerable.

In the experiments here given, it has been the case that calcium salts, in the wet or dry soils, have decreased the solubility of potash in N/5 or N/50 nitric acid. At first sight, this fact seems contrary to the well-established circumstance that calcium salts liberate potash. But when it is recalled that this liberation takes place with aqueous solutions, and nitric acid solutions are not in question, the apparent contradiction disappears. It is rather interesting that calcium salts should cause more potash to dissolve in water and less in N/5 or N/50 nitric acid.

Difference in the Soils.—A marked difference between the good soil (1787) and the others is seen in the fact that calcium

carbonate renders phosphoric acid soluble in it, and does not in the others; while calcium sulphate causes much larger quantities of phosphoric acid to go into solution. A difference in soil 1786 is seen, in that calcium sulphate liberates potash from it, while it fixes it in the others.

EFFECT OF ORGANIC MATTER.

It was necessary to correct the results obtained in the samples to which organic matter had been added. In the first place, the correction already described was made, in order to bring the results to the same amount of ignition residue as the other samples. In the second place, the amount of potash found was corrected for the potash in the sawdust or starch. The correction was made by subtracting from the weight of potassium platinum chloride obtained from the 170 grams of soil the amount obtained from the 13.6 grams of sawdust or starch originally in this quantity of material. The correction was .0208 grams K2Pt C16 for sawdust and .0038 gm. for starch.

This correction was decidedly too high for the sawdust, since it assumed that all the potash contained in it became soluble in N/5 or N/50 nitric acid. As a fact, however, about fifty per cent of the sawdust was practically unchanged at the end of the experiment. In spite of the large correction, positive results were obtained.

The results are presented in Table XII.

TABLE XII.—EFFECT OF ORGANIC MATTER ON PHOSPHORIC ACID (P) AND POTASH (K).

Sample Number.	Treatment.	1786		1787			1788		
		P	K	P	K	K^{n}_{50}	P	K	K_{50}
7	Starch, moist	.0039	.0053	.0059	.0154	.0076	.0060	.0153	.0084
1	Moist	.0047*	.0041	.0070	.0111	.0054	.0075	.0080	.0072
	Gain (+) or lost (−)	−.0008	+.0012	−.0011	+.0043	+.0022	−.0015	+.0073	.0012
9	Sawdust, Moist	.0041	.0044	.0072	.0146	.0057	.0053	.0165	.0076
1	Moist	.0047*	.0041	.0070	.0111	.0054	.0075	.0080	.0072
	Gain (+) or loss (−)	−.0006	+.0003	+.0002	+.0035	+.0003	−.0022	+.0085	+.0004
	Aver'ge gain (+) or loss (−)	−.0007	+.0008	−.0007	+.0039	+.0013	−.0019	+.0079	+.0008

*Dry.

Phosphoric Acid.—In every case except one, the decaying organic matter caused a decrease of phosphoric acid soluble in N/5 nitric acid. For this reason, no correction for the amount of phosphoric acid added in the organic materials was made. Possibly this phosphoric acid was combined with the organic matter to form humic phosphoric acid, although the gain in humus was but slight, as may be seen later. This result is not exactly what was anticipated.

Potash.—In every case, there is a gain of soluble potash by the action of the decaying organic matter. With the sawdust, the gain

should really be greater than the figures given in the table, for the reason given that the correction is too high. But without considering this, there is an average gain of nearly 20 per cent with soil 1786, 35 per cent with soil 1787, and 99 per cent with soil 1788, soluble in N/5 nitric acid. Regarding the solubility in N/50 acid, there is an average gain of about 20 per cent with 1787, and 11 per cent with soil 1788.

The importance of these results can not be too strongly emphasized. They show that the action of organic matter added to the soil is beneficial not only by aiding the soil to hold water, and improving its physical character, but by converting the insoluble and unavailable forms of potash into more soluble and available forms. Under the influence of the carbon dioxide and acids formed by the decay of the organic matter, aided by the activities of the various forms of life which take part in the decomposition, the insoluble compounds of potassium are broken down and rendered more easily soluble in acids. The beneficial effects of stable manure, which, as is well known, extends over a period of years after its application, is due not only to the amount of plant food contained in it, and its physical action on the soil, but also to its action in rendering inert plant food available.

This fact deserves particular emphasis. It is essential, in general farming, to utilize the advantages of the plant food in the soil, before purchasing plant food as a fertilizer, and the presence of vegetable matter, since it aids in the transformation of the locked-up food in the soil, helps to bring about this result. It has been recognized that land can be "run-down," or caused to decrease in fertility, by such methods of cultivation as tend to decrease the store of vegetable matter in the soil, while worn-out land can be "brought up" by methods of treatment which place vegetable matter in the soil, such as liberal use of stable manure, and ploughing under of green crops, or placing the land in pasture and ploughing under the sod.

We must bear in mind that a very large proportion of organic matter (8 per cent) was added to the soil, and the results are necessarily somewhat greater than would be the case in the field.

Snyder [Minnesota bulletin *53*, (1897)] published results which show that organic matter increases the amount of plant food in the soil combined with the humus. He mixed meat scraps, cow manure, and other materials with samples of soil and allowed them to decay a year. At the end of that time, the humus was determined in the usual way (the soil is first extracted with 1 per cent hydrochloric acid). More phosphoric acid was present in the humus in the samples at the end of the period, than was originally contained in the humus and organic matter which was added, showing that in the process of decay some of the constituents of the soil had been caused to enter into combination with the humus.

DECAY OF ORGANIC MATTER AND FORMATION OF HUMUS.

Humus is the organic matter which dissolves in ammonia after calcium salts have been extracted with 1 per cent hydrochloric acid. It is generally supposed that the humus is considerably more important than the other organic portions of the soil.

Although not started with that object in view, data were obtained in these experiments regarding the decay of organic matter and the formation of humus. The amount of humus, moisture, and loss on ignition were determined in the samples to which organic matter had been added, at the beginning of the experiment, at the end of three weeks, six weeks, and the end of the experiment. The determinations, as a rule, were made in duplicate, on samples of soil from two different jars.

As the amount of moisture, and, necessarily, organic matter, would vary during the experiment, all results were calculated to a fixed standard, namely, to ignition residue. Loss on ignition would be the organic matter and the water retained after drying at 100 degrees. The latter should be constant, or nearly so, for a given weight of ignition residue, so that the loss on ignition may be taken to give an idea as to the changes in the organic matter.

The sawdust used was coarser than would have been used had this portion of the investigation been contemplated at first. For this reason, it was hard to get a good sample for analysis, and the figures for organic matter in some cases vary somewhat unexpectedly. However, the results in general are what might be expected.

In calculating the amount of organic matter present at the beginning of the experiment, the loss on ignition of the soil and of the organic matter, the water in the soil and in the starch or sawdust, were all considered, and the whole calculated to 100 grams ignition residue of the soil.

HUMUS FORMATION.

The results of the work are presented in Table XIII. Under the heading "organic" is given the loss on ignition, which includes water retained at 100 degrees as well as organic matter. As stated, all the figures are calculated on the basis of 100 parts ignition residue.

TABLE XIII.—HUMUS FORMATION.

Soil.	Time.	Starch. On Ignition Residue. Organic	Starch. On Ignition Residue. Humus	Starch. Gain (+) or Loss (—) Organic	Starch. Gain (+) or Loss (—) Humus	Starch Converted to Humus.	Sawdust. On Ignition Residue. Organic	Sawdust. On Ignition Residue. Humus	Sawdust. Gain (+) or Loss (—). Organic	Sawdust. Gain (+) or Loss (—). Humus	Sawdust Converted to Humus.
		Per ct.	*Per ct.*			*Per ct.*	*Per ct.*	*Per ct.*			*Per ct.*
1786	Beginning	8.68	.67	....	....	....	8.96	0.67	....	....	
	3 weeks	8.04	.75	—.64	+.08	+1.3	9.04	0.89	+.08	+.22	+3.0
	6 weeks	....	....	....	....	....	6.44	0.94	—2.60	+.05	+0.7
	6½ months	3.33	.67	—4.71	—.08	—1.3	6.35	0.70	—.09	—.24	—3.2
	Total	....	....	—5.35	0	0	....	....	—2.61	+.03	+0.4
	Per cent loss	....	....	.75	....	....	....	....	35	....	....
1787	Beginning	11.49	1.35	....	....	....	11.79	1.35	....	....	....
	3 weeks	10.38	1.54	—1.11	+.19	+2.7	10.97	1.64	—.82	+.29	+.40
	6 weeks	9.36	1.48	—1.02	—.06	—.9	9.29	1.62	—1.68	—.02	—.3
	6½ months	4.65	1.41	—4.71	—.07	—1.0	9.55	1.49	+.26	—.13	—1.8
	Total	....	....	—6.84	+.06	+.8	....	....	—2.24	+.14	+1.9
	Per cent loss	....	....	.95	....	....	....	....	30	....	....
1788	Beginning	8.67	0.56	....	....	....	8.95	0.56	....	....	....
	3 weeks	7.66	0.63	—1.01	+.07	+0.9	6.45	0.84	—2.50	+.28	+3.7
	6 weeks	6.08	0.79	—1.58	+.16	+2.1	5.85	0.81	—.60	—.03	—.4
	6½ months	2.35	0.74	—3.73	—.05	—.5	6.20	0.86	+.35	+.05	+.8
	Total	....	....	—6.32	+.18	+2.5	....	....	—2.75	+.30	+4.1
	Per cent loss	....	....	88	....	....	....	....	37	....	....

General Observations.—There is first a gain of humus during the first period, then a loss in later periods. At the end of the experiment, the greatest gain of humus had been made in soil 1788, the next greatest in soil 1787, and the least in soil 1786. The gains are in the same order, whether the humus from sawdust or starch is considered. There thus seems to be a variation in the capacity of soils to convert organic matter into humus, and retain it.

Considering the amount of organic matter added to the soil, the quantity of humus formed is very small. The maximum amount of humus formed from 100 parts of starch is 3.0; from 100 parts of sawdust, 4.1.

At the end of the period, from 75 to 95 per cent of the starch had been oxidized, and from 0 to 2.5 per cent of the quantity added was in the form of humus. Only from 30 to 37 per cent of the sawdust had been lost; 0.4 to 4.1 per cent remained as humus. There is thus a difference in the capacity of different substances to serve as sources of humus.

All the preceding statements are based on the assumption that the humus originally in the soil was unchanged during the experiment. If any of it was oxidized, the amount of humus formed must have been larger.

It is plain, from what has been said in the preceding section, that the organic matter not humus contained in soils is of importance, inasmuch as in its decay, and in its partial conversion into humus, it aids in the weathering of soils.

SUMMARY.

(1) The factors of availability of plant food in the soil are: the amount of plant food which is present in forms of combination that can be taken up by the plant; the physical condition of the soil; the amount of plant food converted into assimilable forms during the period of growth of the plant; the feeding power of the plants.

(2) Weathering availability is the amount of plant food converted into assimilable forms during the growth of the plant. The rate of weathering depends on the form of combination of the elements, the nature of the soil, the moisture, the temperature, the organic matters and other substances in the soil.

(3) Nitric acid of N/50 strength dissolves from 40 to 80 per cent as much potash as N/5 nitric acid from samples (differently treated) of one soil, and from 50 to 90 per cent from another.

(4) The amount of phosphoric acid soluble in N/5 nitric acid may increase or decrease in a moist soil after standing four months, but increases if calcium sulphate is present.

(5) An increase in the amount of potash soluble in N/5 nitric acid takes place in a soil kept moist four months, with or without the presence of calcium sulphate. The presence of calcium carbonate has a tendency to decrease the amount of potash dissolved. There is a difference in the behaviour of the three soils, one showing a tendency to decrease in soluble potash, while the other two increase. In the same samples, the quantity of potash soluble in N/50 acid has decreased.

(6) The effect of moist calcium carbonate is to reduce the solu-

bility of phosphoric acid in N/5 acid as compared with dry calcium carbonate.

(7) In one soil, calcium carbonate increases decidedly the amount of phosphoric acid soluble in N/5 acid, and in two soils it decreases the amount. It causes a decrease in the amount of soluble potash in every case.

(8) Calcium sulphate increases the amount of phosphoric acid soluble in N/5 acid, particularly in one of the soils. It causes a decrease in the solubility of potash in two cases and a decided increase in one.

(9) There is no contradiction in the fact here brought out that calcium salts decrease the amount of potash dissolved by N/5 or N/50 nitric acid, and the fact that calcium salts cause more potash to go into solution in an aqueous extract of the soil—"liberates potash."

(10) The decay of organic matter (starch or sawdust) in a soil caused a decrease in the amount of phosphoric acid dissolved, but a great increase in the amount of potash, from 20 to 99 per cent with N/5 acid, and from 11 to 20 per cent with N/50 acid.

(11) Organic matter not only changes the physical character of a soil, but it accelerates the action of weathering in converting insoluble potash into available forms. Stable manure is of value not only for the plant food actually contained in it, but also for that which it will liberate by its decay from the soil.

(12) There is a variation in the power of soils to convert organic matter into humus and retain it. In three soils, the amount of humus gained from starch at the end of six and a half months was .0; .06; .18: and from sawdust .03; .14; .30 per cent of the ignited soil.

(13) A relatively small amount of organic matter added to soils is converted into humus. The maximum obtained in this work was 3.0 per cent of the starch and 4.1 per cent of the sawdust, though from 75 to 95 per cent of the starch and from 30 to 37 per cent of the sawdust disappeared during the four months.

(14) There is a difference in the capacity of organic materials to serve as sources for humus.

(15) Organic matter not humus is probably of great importance in the soil, inasmuch as it decays more rapidly, and in its decay aids the weathering of soils.

This work will be continued.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 9.—MAY 1, 1903.

TO PREVENT THE BLACK ROT OF THE GRAPE.

The black rot can be quite effectively controlled with a little proper care and attention. The following is a summary of the treatment to be recommended:

1. Gather up and destroy all old leaves, rotten grapes and other trash in the vineyard; and cultivate the ground so as to cover such material as can not otherwise be disposed of.

2. Keep the vines in as healthy, vigorous condition as possible by the use of proper cultivation and fertilizers.

3. Spray thoroughly at least six times during the season. First use copper sulphate, six pounds of copper sulphate to a barrel of water applied to parts and vines before the leaves appear. Second, use Bordeaux mixture (5 pounds of copper sulphate, 5 pounds of lime, 50 gallons of water) after the leaves and fruit buds appear, but before the flowers open. Third, just after blossoming, when the fruit is about ten days old. The other sprayings may follow at intervals of ten days. Increase the strength of the Bordeaux mixture in hot, muggy weather by the addition of a little more copper sulphate and lime.

4. Be careful to make the Bordeaux mixture properly and use a fine nozzle in spraying.

5. In so far as possible, pick off and destroy the diseased leaves and berries that you may notice.

6. If your vineyard appears to be overrun with the black rot, and seems to be for this year profitless, do not neglect it. Such a season is just when the vineyard needs the most care. Give it a thorough treatment and stamp out the infection.

(Extract from *Bulletin* on "The Black Rot of the Grape" soon to be issued.)

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 10.—AUGUST 8, 1903.

THE WATERMELON WILT.

The watermelon wilt is causing great damage to the watermelon industry in North Carolina this year, cutting down seriously the amount of fruit raised, and in many cases reducing the crop to absolutely nothing. Whole fields present but a mass of dead vines. The present year shows the disease in a much more destructive form than this State has known it before, although the story is old in many of our sister Southern States, where the raising of melons has to be largely abandoned.

The disease can not be cured, nor can it be wholly prevented, yet with proper precaution its spread into fields not now infected can be retarded or entirely avoided.

The wilt is readily recognized from the fact that the leaves first droop, as though they were suffering from want of moisture, rapidly wilt and soon die, the runner dying with the leaves. Soon the whole plant is dead. Upon cutting the main tap root across near the surface of the ground, such plants are found to present a yellow color, making a distinct contrast with the white color of the healthy plants. This one character taken together with the wilted appearance of the vine, will enable any one to recognize readily the true watermelon wilt.

This disease is caused not by insects, but by a very small microscopic germ, a fungus, which lives in the soil. It is so small that millions may exist in one teaspoonful of soil. This germ is able to live in the soil for some considerable length of time. Therefore, if your field suffers from the wilt this year, it would be folly to plant that field in melons against next year or year after. It must be abandoned for the culture of melons until the germ in the soil dies. How long that will take is not yet certain. The germ has been known to live in the soil for four years after watermelons had ceased to be raised there. It will be seen from this that there is very little hope of ever getting rid of this disease when it is once in a field. It therefore behooves us to give especial care to prevent the disease from spreading into fields which are not yet diseased.

The spread of the disease may occur in the following ways:

(1) Soil which is removed from a diseased field into another field, for example by washing, or by tools, may carry these germs with it.

This would indicate that tools should be thoroughly cleaned before being carried from the infected field to the healthy fields.

(2) Diseased plants carried in any way or blown from the diseased field to the healthy field carry the contagion. One common way in which these vines are carried is by cattle. The cattle spread the disease by carrying it into healthy fields and leaving it, in the manure, the germ uninjured.

With these points in mind, a few suggestions can be made as to the restriction of the disease to its present confines.

First. Rotate your crops. You may grow anything else that you wish on this land, but do not replant it to watermelons until you are sure that the watermelon wilt germ in the soil is dead. This will probably take more than four years, and even at the end of that time you had best try it with a few hills before planting the whole field to melons.

Second. Remove and burn all diseased plants. This will prevent the formation of a very great number of spores, and thus diminish the contagion. Go into your diseased field and pull and burn all diseased plants as soon as you see them. If your whole field is diseased, pull and burn all melon plants in order to prevent their spread by the wind, and to prevent them from passing into the hay crop, and thus infecting your manure for next year.

Third. Do not allow cattle to pasture on diseased vines, and thus spread it through the manure.

Fourth. Clean your tools so as not to carry the germs from infected fields to uninfected fields. Remove the dirt from all the tools. A teaspoonful of dirt may contain thousands of germs.

Fifth. Do not use any manure which by any possible means may have been contaminated with the watermelon wilt. The manure may be contaminated in two ways: first, by trash from the field being thrown on the compost heap; second, by feeding to the stock cowpea hay in which there may be traces of diseased watermelon leaves, stalks, roots, fruit, etc., the germs pass through the cow into the manure uninjured.

The practice of raising watermelons before cowpeas leads to the presence of some watermelon vines in the cowpea hay, and this likewise leads to the presence of germs in the compost heap. Such manure should never be placed on land which is still free from the germ, or which is to be used to raise watermelons on, as this is an almost sure way of spreading the wilt.

There is no objection to the use of stable manure which does not contain the fungus, *but experience has shown that when the wilt once gains entrance to the compost heap or barnyard, that it remains there for years,* and all of the manure taken out of such a yard will be likely

to spread the disease. Hence it is exceedingly dangerous in regions where there is any possibility of the wilt, to use any stable manure on the field where you intend to plant melons.

The outlook for the melon industry is not encouraging, and the treatment that can be recommended for this disease is not very promising, but for this very reason it is all the more evident that any person who still possesses an uninfected field, should exercise the greatest care with his tools, cattle, manure, and take every precaution possible to preserve that field in its present uninfected condition. With the present scarcity of watermelons, and the promise of a still greater scarcity in the future, the value of uninfected fields rises rapidly.

IMPORTANT NOTICE.

It is the desire of the Station to do everything possible to assist the watermelon growers in combatting this disease. To this end, we desire to know where, and how abundant, this disease is at present, and ask that every grower who is affected with the wilt, write to the Station, stating the amount of damage, and what he knows of the history of the disease in his region. Pull up a diseased plant and cut off the runners about three inches from the root and send with your letter this root with the stubs of the runners on it.

F. L. Stevens,
Biologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 11.—AUGUST 22, 1903.

A DANGEROUS TOBACCO DISEASE.

A very destructive tobacco disease has recently broken out with extreme violence in certain portions of the State. It is the desire of the Station to accumulate all information concerning the disease which may lead to a checking of its ravages. The point now most to be desired is to find out how widely the disease is distributed over the State. To that end we request that all people interested in tobacco growing, who are troubled with any disease of their tobacco plants will send specimens, consisting of the lower part of the stem and roots, to the Station. We particularly desire these specimens if the disease consists of the wilting of the leaves, accompanied by a brown color in that portion of the stem just inside of the bark. We urge upon all tobacco growers the importance of notifying the Station immediately after this disease appears in the neighborhood, so that we may advise as to the means of preventing its spread. Two diseased stalks in the field this year may mean the loss of the entire crop the next year you put tobacco on the field.

F. L. Stevens,
Biologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 12.—OCTOBER 25, 1903.

BLACK ROT OF THE CABBAGE.

For more than fifteen years there has existed in North Carolina a very serious disease of cabbage and other crops of the cabbage family. The annual damage in this State from this disease is probably more than $10,000. Besides cabbage, upon which it most frequently operates, this disease attacks turnips, kale, cauliflower, mustard, rape, and in fact all crops and weeds of the cabbage tribe.

The disease in cabbage is characterized by the outermost leaves of the plants, near the edges, turning first yellow, then brown and finally black. The disease spreads downward into the main stem and through this into the inner leaves of the head. While no plant of the cabbage kind is wholly exempt, those of a loose or spreading habit like the collard are less damaged than those which form close heads, like the flat Dutch type. The disease is very contagious, spreading from plant to plant in the field. Frequently large patches of cabbage apparently healthy one day are found soft and rotten the next. The disease is always most virulent in hot, moist weather.

Cause of the Disease.—Black Rot of the cabbage and other plants of the same family, is caused by a germ or microbe, *Bacillus campestris.* This germ lives from year to year in the soil, attacking with increasing virulence successive crops of the cabbage kind, until at length it becomes practically impossible to grow these crops except upon fresh or virgin soil. The germ increases rapidly only during the warmer months of the year, or while the temperature is above 80 degrees F.

Treatment.—The treatment for Black rot must be preventative. Spraying is of no value in this case. Rotation of crops so that no crop of the cabbage family shall come upon the same field oftener than once in three or four years is the first and most essential precaution. The seed-bed should be made upon fresh ground each year, or the bed should be burned over as is done for tobacco beds, to kill possible germs in the soil. Cabbage, turnip and all other crops of this family should be grown only during the cooler months, or while the temperature is below 80 degrees F. If only a few scattered plants in field show the characteristic yellowing or blackening of

the leaves, such plants should be pulled up and burned. Do not throw diseased cabbage leaves or plants upon the manure pile. The germ can live for an indefinite period in the manure, and will be scattered over the fields with the manure. In cultivating a field which contains diseased cabbage or other plants of this family, before going into another field clean all tools carefully and thoroughly to avoid carrying the germs into fields as yet free from them. Wage a vigorous war against shepherd's purse, pepper grass, and all other weeds of the cabbage family, as these may serve to propagate the disease during years in which other crops occupy the land.

Except as stated above, no particular variety of cabbage is exempt, and no special brand of seed will ensure freedom from the pest.

GERALD MCCARTHY, *Biologist,*
N. C. Department Agriculture.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 13.—JANUARY 7, 1904.

THE SILK-GROWING SEASON OF 1904.

The public interest in the revival of silk growing in the United States continues unabated. Substantial progress has been made during the year just closed, and the prospects are good for increased output of silk cocoons the coming spring. Silk-growing associations are being formed in many States, and public schools are introducing the study into their systems. Among the latest formed associations are the American Silk Growing Association of Vineland, N. J., of which the President is the well known financier, Hon. Wharton Baker of Philadelphia. The Silk Growers' Association of Patchogue, Long Island, has been organized with Dr. Franklin Sylvester, of New York, as president. A number of towns in Michigan grew silk in 1903. In California the industry is centered about San Diego, where there are quite a number interested. In Georgia the Tullulah Falls Company are increasing their plant, and an industrial school to teach silk growing and domestic arts has been planned there and will soon be in operation. Steps are being taken to establish a school similar to that at Tullulah Falls in Western North Carolina. Silk culture in America has come to stay. When carried on as we have recommended, as a household industry to occupy spare time of the women, children and aged or feeble members of the family, silk growing can not fail to fill an important place in our social economy. It will furnish useful and remunerative employment for labor otherwise unproductive. It will add to the comfort and happiness of the aged and young and poorer classes of our population. It will make country life more bearable to the young of both sexes who now look even to life in the factory towns as a relief from the hardships of the farm.

But silk reels and silk weaving mills must necessarily follow the establishment of silk farms, and the State which fosters silk growing will in the end secure a bountiful reward in general prosperity. North Carolina can easily and without detracting from any profitable industry already established, add to the wealth produced in the State not less than $6,000,000 annually. This is a sum worth striving for.

The North Carolina Department of Agriculture will import from Italy in February a sufficient quantity of silk worm eggs to supply

all silk growers in the State who make application in time, or during the month of January. The prices of eggs will be the same as last year, viz.: Per ounce, $3.00; per one-half ounce, $1.60; per one-quarter ounce, 80 cents; per one-eighth ounce, 45 cents. No one without previous experience should attempt more than one-eighth ounce the first year. Those who have had experience and who have a supply of mulberry leaves at hand may attempt a full ounce. The Department will find a market for all the good cocoons produced in North Carolina this year at $1.00 per pound for choked cocoons. There need be no fear that the market will be over-supplied. We can sell any amount at the price named. The Department makes no charge for its services to citizens of the State.

We still can supply, to farmers only, rooted mulberry trees suitable for feeding silk worms for $1 per hundred postpaid. A small number of copies of Silk Bulletin, No. 181, still remain, and will be sent free to those wishing to take up silk culture. A new circular giving estimates and detailed drawings for erecting scaffolding and building trays upon which to grow the worms will be issued next month. From these directions any one handy with tools can construct all the apparatus needed out of common pine lumber.

More silk-growing associations will be organized in North Carolina. This affords a good opportunity for far-seeing and philanthropic persons in every community to benefit their neighbors by organizing such associations and starting silk growing. The governing bodies of almshouses, hospitals and girls' schools should also take steps to introduce this industry with a view of enabling their populations to earn a little money each year without any great risk or hardship. Teachers in graded schools might well introduce the care of silk worms as a species of nature study as well as a profitable art.

Applications for silk worm eggs and mulberry trees should be made to the undersigned, and must in every case be accompanied by the full amount of cash in postage stamps or money orders.

Address, GERALD MCCARTHY, *Biologist,*
N. C. Department of Agriculture, Raleigh, N. C.

Bulletin No. 186 **July, 1903**

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

INSECT AND FUNGUS ENEMIES

OF THE

PEACH, PLUM, CHERRY, FIG AND PERSIMMON.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

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A. F. BOWEN.....Bursar.

The Director's office is in the Agricultural Building Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times. and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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INSECT AND FUNGUS ENEMIES OF THE PEACH, PLUM, CHERRY, FIG AND PERSIMMON.

By F. L. STEVENS, Biologist, and FRANKLIN SHERMAN, Jr., Entomologist.

I. Insect Enemies.

By FRANKLIN SHERMAN, Jr., Entomologist.

a. INSECTS ATTACKING THE CHERRY.

1. Attacking Trunk or Branches.

THE FRUIT BARK-BEETLE (fig. 1).

(Scolytus rugulosus, Ratz.)

Description.—A small black or brown beetle, about one-tenth of an inch in length, which bores little holes through the bark into the sap-wood. Often they attack a tree in great numbers and tree dies from the attack.

Life History and Habits.—These insects do not usually attack a tree that is in good health. Their attacks are most often confined to

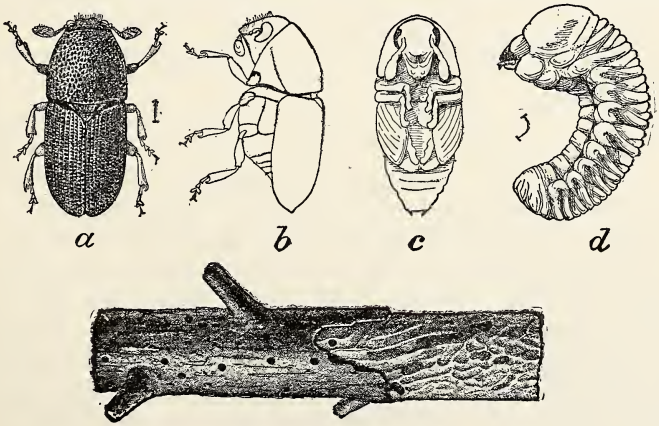

Fig. 1—Fruit Bark Beetle.
(After Chittenden, U. S. Dept. Agr.)

trees which have been injured by some other cause, as by lack of cultivation, or severe injury by storm, breaking of branches, etc. The

adult beetles bore into the bark and sap-wood and there deposit the eggs. The eggs hatch to tiny white grubs, which do still further damage by boring in the sap-wood, often to the extent of killing the tree. These little grubs finally become mature and transform to the pupa stage, from which the adult develops.

Remedies.—As already stated this pest does not usually attack healthy trees and the most important factor in control of the insect is to keep the trees in good health so that they will not be attacked. After the trees have been so neglected as to furnish a suitable place for these beetles, it is not surprising that they should quickly die when attacked. If a tree becomes thickly infested with them it had best be removed and burned without delay. If only certain branches are affected they should be removed and burned. Parts only slightly infested may be treated by rubbing them thoroughly with a rag saturated with pure kerosene in winter while the trees are dormant.

THE SAN JOSE SCALE (fig. 5).

(*Aspidiotus perniciosus, Comstock.*)

Description.—Very small insects of yellow color, the bodies of which are covered by a round grayish covering or scale. They attack the branches principally, but if the trees are young they may be on the trunk as well. When numerous, they so completely cover the bark as to render it of a grayish color, looking as if dusted over with ashes. The insects after becoming covered by the scale are incapable of movement, hence are not easily noticed.

Life History and Habits.—The life history of the insect is quite fully discussed under the head of "Insects Affecting the Peach," on page 12 of this bulletin. It is not necessary, therefore, for us to repeat it here.

Remedies.—Trees infected by this insect should be thoroughly treated during the winter with kerosene emulsion at the strength of 25 per cent oil. The formula for preparing this emulsion and reducing it to the desired strength is given in the Spraying Bulletin.

Cherry trees are so resistant to the attacks of this insect that they are not nearly so quickly killed by it as are peach, pear, plum and apple trees. In fact, we have seen cherry trees that had been infested for several years and which were still alive. But such a tree is a menace to other fruit trees around and therefore should be treated to keep it from spreading, if possible. One thorough treatment every two years will keep the insect in subjection on the cherry, though other infested fruit trees have to be treated every year. Trees which are to be treated for this pest should be well pruned before treatment, so as to effect a saving of the emulsion.

2. Insects Attacking the Leaves.

CATERPILLARS, VARIOUS SPECIES.

Caterpillars are hatched from eggs which are laid by moths or butterflies. There are a number of kinds which may attack the foliage of the cherry, though it is not often that their injuries are serious.

Remedies.—When any species of caterpillar becomes destructive to the foliage of the cherry it may be easily subdued by giving the tree a prompt and thorough spraying with Paris green and water at the rate of one pound of Paris green to 150 gallons of water. Add as much lime by weight as is used of the Paris greeen. Stir the mixture thoroughly.

LEAF-CHAFERS, VARIOUS SPECIES.

The insects to which the name of "Leaf-chafers" is applied are brownish or yellowish beetles which are especially numerous in spring and early summer and sometimes settle on cherry or other trees in great swarms, defoliating them by completely devouring the leaves. There are a great number of these beetles, all being more or less closely akin to the green June-bug with which we are all familiar. The beetles usually lay their eggs in grassy fields or pastures and the grubs which hatch from them live on the tender roots of the grasses. When fully grown these grubs change into pupæ, which in the course of a week or two transform into adult beetles which then proceed to lay eggs for another generation.

Remedies.—The spraying of trees with Paris green, lime, and water, as just mentioned for caterpillars, will prove efficient in killing these beetles. It is necessary to be very prompt, however, for the insects will often settle on the trees by thousands and do serious damage, even in a single night. They are nocturnal, beginning to fly after sunset.

3. Insects Attacking the Fruit.

THE PLUM CURCULIO (fig. 6).

(Conotrechellus nenuphar Herbst.)

Description.—A dark gray or brownish beetle about 1-4 inch long, which scars or "stings" the fruit when young, laying an egg in each of the punctures in the fruit. The egg hatches into a white grub which bores through the flesh of the fruit to the pit. This causes the cherry to become soft and often rot, though they do not usually fall from the trees.

Life History and Habits.—These have been quite fully described under the head of "Insects Affecting the Peach," on page 17 of this bulletin.

Remedies.—If a grower has a number of trees and suffers considerable loss from this insect it will pay him to jar the trees in the spring of the year as is recommended for destroying this pest on peaches on page 18 of this bulletin. When there are only a few trees or if they are very large this is hardly worth while or practicable, in which case nothing better can be done than to spray the trees at least twice with Paris green, lime and water; First, as soon as the leaves are about half expanded; Second, ten days later. Use at strength of 1 ounce Paris green to every 10 gallons of water, adding as much lime by weight as is used of the Paris green, and stir the mixture thoroughly.

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b. INSECTS ATTACKING THE FIG.

1. Attacking the Fruit.

THE FIG-EATER, OR JUNE-BUG.
(Allorhina nitida, Linn.)

Description.—A greenish beetle nearly an inch in length, which flies with a loud buzzing sound, which sometimes eats the ripe fruit of the fig. Familiar to us all under the name of "June-bug."

Life History and Habits. The June-bug lays its eggs in grassy lands or pastures and the eggs hatch into white grubs. When gardens or strawberry beds are planted directly in sod land they are apt to be infested with white grubs, which were feeding on the roots of the grasses. It takes the grubs two years to reach maturity, when they transform into pupæ, which then change again into beetles which lay the eggs for another generation.

Remedies.—The only remedy thus far known to use against this beetle when they attack the fig is to jar them from the bushes and kill them.

It seems that the insect must not do much damage to the fig in this State, for we have had no report of injury by it in over two years. We mention it as it is recorded in other works as an enemy to the fig. We should be interested to hear from any who suffer from the attacks of this insect on the fig.

c. INSECTS ATTACKING THE PEACH.

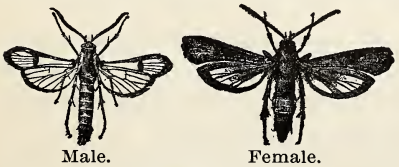
General Remarks.—While the insect enemies of the peach are not so numerous as those of the apple, yet the peach probably suffers even more if these pests be neglected. The peach tree is a tender plant, easily hurt by neglect, frosts, fungi or insect enemies. It is often extremely difficult to treat peach trees for certain pests, as they are so tender that an application which will kill the pests may also injure the tree. Skill, care, promptness and thoroughness are therefore essential in treating this tree for insect enemies, and even the least carelessness will often cost the life of the tree. Even with the best of care the results are often very imperfect.

1. Attacking Trunk or Branches.

THE PEACH TREE BORER (fig. 2).
(Sannina exitiosa, Say.)

Description.—White "worms" which bore into the bark and sap-wood of the tree at the surface of the ground, causing a large amount of gum to appear at the injured part. Often they completely girdle the tree, thus killing it.

Life History and Habits.—The Peach Borer, as we commonly know it, is a sort of "worm." These are hatched from eggs which are laid in summer from June to October by a female moth. This moth flies by day and very much resembles a wasp in appearance, being of a steel-blue or black color marked with a yellow band around the body. The eggs are deposited on the trunk of the peach trees at the surface of the ground and hatch into the white caterpillar, which bores in to the bark and lives in the inner bark and sap-wood. They become fully grown in spring and leave the tree and spin a silken cocoon on the outside of the tree or a few inches away in the earth. Within the cocoon the caterpillar passes through the transformation to the adult moth which then emerges, mates and lays the eggs for another generation.



Male. Female.

FIG. 2—Peach Tree Borer.
(After Riley. 1. Missouri Report.)

Remedies. — To successfully combat this pest the fuit-grower must be thorough and persistent in his work against it. In early spring (March is the best month for the greater part of North Carolina) the trees should be gone over carefully and all showing signs of the borers should be "wormed." The gum and rough bark at the base of the tree is scraped away

and one or two inches of the earth removed. With a stout knife probe about and kill every worm which can be found. After the tree has thus been freed of the worms hill the earth up against the base for four or five inches above the normal level, so that the moths will have to lay their eggs higher on the trunk of the tree. This mound is left until December, when it is removed again so that the worms will be exposed to the cold of winter. Then in March the trees are wormed and mounded again as before.

By this means the moths are compelled to lay their eggs higher on the trunks of the trees and thus they are easier to reach and kill. In addition to this, many of the young worms will not be able to bore into the rough bark on the trunk and will perish.

Special Note.—There is a little, slender white worm, *without a distinct head,* which lives within the gum which exudes from the base of the peach tree. These are not the borers and have nothing to do with them, and they do not injure the tree. The Peach Borer is rather a stout-bodied worm with a very distinct brown head.

THE FRUIT BARK-BEETLE (fig. 1).

(Scolytus rugulosus, Ratz.)

Description.—Small black or brownish beetle, about one-tenth of an inch in length, which bores little holes through the bark into the sap-wood. Often they attack a tree in great numbers. Little drops of gum exude from the holes made by these insects in peach trees.

Life History and Habits.—These have been sufficiently explained under the head of "Insects Attacking the Cherry," on page 5 of this bulletin, so that no further discussion is needed here.

Remedies.—The remedial measures recommended for this insect are described on page 6 of this bulletin.

THE PEACH TWIG-BORER (figs. 3 and 4).

(Anarsia lineatella, Zell.)

Description.—Small pink or reddish caterpillar with black head, which bores into the tender growing shoot in spring about the time the leaves are becoming expanded. Kills the young twig for several inches. Often enters at base of a bud or young shoot.

Life History and Habits.—The little caterpillar which does this damage is hatched from an egg laid by a moth. The moths of the Peach Twig-borer are shown in the accompanying figure. The life history of the insect as it exists in the Eastern and Southern States is not well known. When fully grown the larva spins a thin web

in the dried leaves or rubbish in the twigs of the tree, or near it on the ground. There it changes to the pupa (as shown in the figure) and from this the adult is developed. There are thought to be two broods of the insect each year.

FIG. 3—The Peach Twig-borer. *a*, work of the larva in growing shoot; *b*, larva, which does the injury; *c*, the pupa into which the larva transforms.
(After Marlatt, U. S. Dept. Agr.)

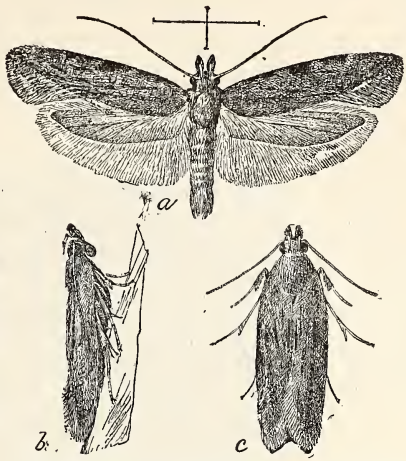


FIG. 4—The Peach Twig-borer. *a*, adult moth with wings spread; *b*, view of moth from side; *c*, view of moth from above.
(After Marlatt, U. S. Dept. Agr.)

Remedies.—The most commonly used and most satsifactory method of dealing with this pest is simply to clip off the withering shoots as soon as the injury becomes apparent and burn them. In this way the larvæ within the twigs are destroyed.

LECANIUM—SCALE-INSECT.

Description.—Scale insects which are of soft consistency, the scale not being distinct from the body. They are nearly hemispherical in shape and brown or yellowish in color. Only the young insects crawl about, the older ones remaining attached to the bark.

Life History and Habits.—The only complaint of Lecanium on peach in this State has come from Buncombe county, but as the writer knows that it is quite injurious in Western Maryland, where the conditions of soil and climate are quite like those of Western North Carolina, it is worth while for our peach-growers in the west to be on the watch for it.

The full-grown Lecanium scales are about one-eighth of an inch in length(and are very convex, having the appearance of little brownish knots or galls on the twigs. Like most scale-insects they are attached to the bark, so that they do not crawl about, only the young insects being able to move from place to place. The young

insects after crawling about for a few hours insert their little beaks into the bark and begin to suck the sap. Then the outside covering of the body becomes hardened and they shed off the skin with the legs, so that they thereafter are incapable of moving about. They are very easily rubbed from the bark or crushed, and when crushed they give an odor which (to the writer) is nauseating, though this odor is not very strong.

Remedies.—The Lecanium is very easily controlled by spraying during the winter with kerosene emulsion at the strength of 15 or 20 per cent oil. Full directions for preparing this emulsion are given in the Spraying Bulletin.

The treatment should be made during winter when the trees are dormant. One thorough treatment will so check the pest that it will not again become destructive for several years. In using the kerosene emulsion on peach trees be careful not to allow it to run down the trunk and in at the roots. Only use just enough to thoroughly dampen all the bark.

THE SAN JOSE SCALE (fig. 5).

(Aspidiotus perniciosus, Comstock.)

Description.—A small yellowish-colored insect, which is covered by a circular, flattened, grayish covering or scale. The insect attacks the branches of trees, often also on the trunk, especially when the trees are young. When a tree is badly infested the scales may be so thick as to overlap one another, covering the bark completely and giving the tree a grayish appearance as if dusted over with ashes. Attacks most deciduous fruit trees, but is seldom found on forest trees. Keiffer, LeConte and Garber pears are seldom attacked.

Life History and Habits.—The San Jose Scale has been the cause of much alarm among fruit-growers, and indeed, it is a serious pest if left to run its course in an orchard. But it can be kept in control if the proper remedies are thoroughly and regularly applied. We give quite a full account of this insect. The scale itself (which is all that is visible as it exists on the tree) is separate from the body of the insect. The insect lies directly beneath the scale, and is of a yellow color, closely resembling a small bit of cheese or butter. The scale of a full-grown female insect is about as large around as a good-sized pin-head. When the insects are thick and crowded on a twig the scales do not attain so large size. Beneath this scale the insect lies, with its slender beak thrust into the bark, sucking the juices. The females give birth to living young which are so small as to be barely visible to the naked eye. When first hatched the young insects are able to crawl about, but after a few hours they,

too, insert their beaks into the bark to suck the sap. After once inserting the beak they do not remove it, but remain attached at that spot. Soon the skin is shed, and with the skin the legs and antennæ (feelers) are also lost. The shed skin helps to form a covering over the body, which is added to from time to time, becomes harder, and is the *scale* which covers the insect. In the figure the insect will be seen depicted in various stages of growth. Near the upper end of the figure are some of the young crawling lice. The small, round,

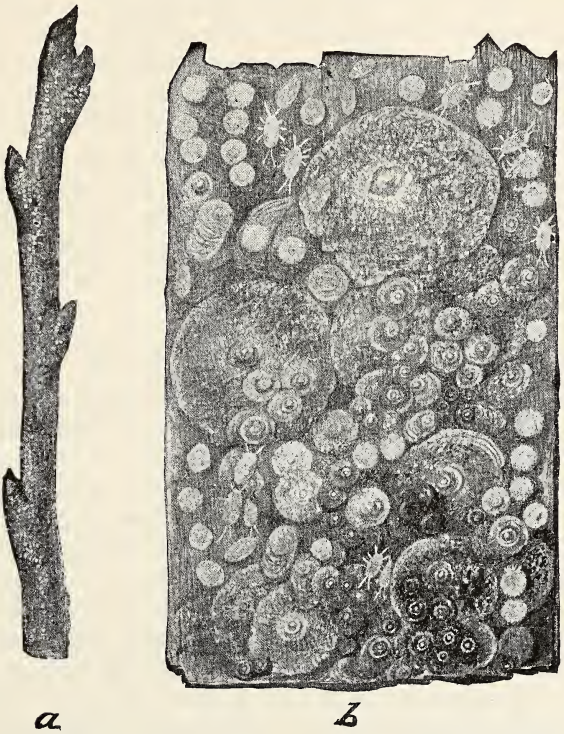


FIG. 5—The San Jose Scale. *a*, appearance of infested twig, natural size; *b*, appearance of infested twig under magnifying glass.

(After Howard and Marlatt, U. S. Dept. Agr.)

light-colored objects are those over which the scale is just forming, while the larger, round, blackish or grayish ones are the half or full-grown scales.

The development of the two sexes is different. Near the upper left-hand corner of the figure will be noticed two scales which are oblong in shape. These are scales of male insects. The largest circular scales are of females. The smaller circular scales are of partly-grown individuals. The male insect finally develops into a tiny yellowish fly, which escapes from beneath its scale. The female insect always remains under the scale and never regains the

power to move about after once settling down on the bark to feed. From the time of birth it takes the males about four weeks to come to full maturity and a little longer for the females. The number of young brought forth at a birth is variable, but usually runs from about six to thirty. Hence it is easy to see that if left unchecked it will soon be so numerous as to kill the tree.

The young insects can not settle down well on old tough bark, as they need to find tender bark which they can pierce with their delicate beaks. Hence if a tree be already old before it is attacked it may not be killed, though the tender growth would doubtless be hurt and the insect could spread from such a tree to others. But if they get on a tree while it is young and the bark tender, they may locate anywhere on the trunk or branches, and if not discovered and promptly treated, they are likely to kill the tree. We often receive twigs which are more thickly infested than that shown in the figure.

In winter the full-grown insects usually die, leaving only the half-grown individuals alive in the spring. But in the warmer sections of the State, and especially in warm winters, the adult insects may live through the winter.

The breeding season begins with the first warm weather of spring and continues until freezing weather in the fall. The exact time of course depends upon the season. In 1902 they began breeding in middle of March in the middle section of the State, and were likely breeding earlier in the eastern section.

The insect can not spread much of its own accord, hence is dependent upon other agencies to get from place to place. It is only when young and crawling that they can be detached from one tree and transferred to another. If the branches of two trees touch, of course the young insects may crawl from one to the other. But for the most part they are dependent on forces outside of themselves. A breeze may blow gently through an orchard and carry the tiny young lice, like particles of dry dust, from one tree to another. In most infested orchards it is noticeable that it spreads most rapidly in the direction with the prevailing winds. Or, a bird may alight in a tree and some of the young lice crawl on its feet or feathers. Then it may fly away into some other tree or orchard where the young insects may become established. Thus it is not possible to tell how far the pest may be carried from an infested orchard. If the country be level and cleared so that wind has free play over the orchards the spread is likely to be fast. On the other hand, if the country is broken and there is much woods intervening between orchards, it will spread more slowly.

Another means by which the scale may be spread is by the sale of nursery stock. A nurseryman may have scale in his nursery and not know it, and thus he may unknowingly do his customers

great injury. It is for this reason that the law requires the nurseries of the State to be inspected each year, and our nurserymen are now introducing the practice of fumigating all of their fruit trees with a poisonous gas before shipping them, so as to kill any insects which may be on them. But of course this does not prevent the scale from attacking them afterward, so that the grower himself must be watchful and careful.

We are often asked how long it will take the San Jose Scale to kill a fruit tree. Of course it will depend upon the kind of tree and how old it is when it becomes infested. If the tree becomes infested as soon as budded, peach and plum are likely to die within from one to two years; apple, pear and cherry in from two to four years. If infested when five years of age, peach and plum will usually die in three or four years, pear in four or five years, and cherry and apple in four to six years, or perhaps not at all. If a tree is free from scale until eight years of age or older, our observation has been that apples are not likely to be killed outright, though peaches and plums may. Of course an infested tree should be regularly and thoroughly treated, whether it is weakened or not, for otherwise it becomes a center from which the scale may spread to other trees or orchards in the vicinity. Furthermore, though a tree may be too hardy to be killed outright, yet the younger branches where the fruit should be borne, may be injured to such an extent that the tree can not mature the crop. If an infested tree is not treated every winter it is liable to be seriously hurt, therefore *those who have infested trees may count on treating them once thoroughly each winter, no matter how thoroughly they may have been treated before.*

At the present time (October 1, 1903), this pest is known to exist in orchards in thirty-five counties of the State; these including Surry, Person and Halifax on the north; Halifax, Bertie, Carteret and New Hanover on the east; New Hanover, Scotland and Gaston on the south, and Jackson, Haywood and Mitchell in the west. We can see, therefore, that it is not limited to any portion of the State, and trees in any section may be infested. At present we know of no case of scale to the east and north of Bertie, Pitt and Carteret counties, but there can be but little doubt of its presence there, even if we have no record of it. New cases are being brought to our notice almost every week. Every grower must, therefore, be watchful, and should at once send to this office any twig which he suspects of being infested with this scale.

*Remedies.**—The remedy used for this pest is kerosene emulsion

*The writer of this article has a special circular relating to treatment for this pest, which will be sent to any one on application. Address FRANKLIN SHERMAN, JR., Entomologist, Raleigh, N. C.

at the strength of 20 per cent oil. Directions for making the emulsion are given in the Spraying Bulletin. The applications can best be made with a spray pump, but if one is not to be had, the remedy may be applied by hand with a brush or rag, if trees are not too numerous.

This remedy can only be applied to trees in winter when they are in a dormant state, and should be applied in fair weather. If applied after the buds have burst it is likely to do very serious injury. If any trees are so badly infested as to make it impossible to save them they should be dug up and burned on the spot, as soon as the trouble is discovered. All other trees that are infested (no matter how slightly) should be marked for treatment the next winter.

Only just enough of the emulsion should be used to thoroughly dampen the bark of the tree. It should not be allowed to run down the trunk and in at the roots. But remember that the application will only kill those insects that are actually touched by it, so that the object should be to dampen every square inch of the surface of the bark.

It is very desirable to trim trees before treating them for this scale, so that it will be easier to reach all the parts and also so that it will not require so much of the material. In any case, those who suspect that their premises are infested are urged to send twigs to this office, together with full information as to the number of trees in the orchard, the number found infested, the age of the trees, and from whom they were purchased. We will then be able to advise more fully and more intelligently.

2. Attacking the Leaves.

BLACK PEACH APHIS.

(Aphis prunicola, Kalt.)

Description.—Small reddish or brownish, soft-bodied, louse-like insects, which sometimes appear in great numbers on the buds in very early spring, sucking the sap from them and often causing them to die.

Life History and Habits.—The life history of this insect is not fully known, and this account is taken from another publication.*

The insect is also found on the roots where it breeds undisturbed. In the spring it makes its appearance at the surface of the ground, where it establishes itself on the new shoots. Here a form is developed which has wings, which fly to other trees and start new colonies. They feed until about midsummer and work their way down to the roots.

* Bul. No. 48, Md. Agr'l Exp. Station, p. 98, by W. G. Johnson.

Remedies.—The pest can be easily destroyed by spraying with kerosene emulsion at 15 per cent oil, but care must be taken to use no more than is necessary to dampen the affected shoots, and it should not be allowed to run in at the roots. A very thorough dusting with tobacco dust will also prove very beneficial. The insect is not commonly destructive in this State, but has done damage in some years. Formula for preparing the kerosene emulsion and diluting it are given in the Spraying Bulletin.

3. Attacking the Fruit.

THE PEACH AND PLUM CURCULIO (fig. 6).

(Contotrechellus nenuphar, Hbst.)

Description.—A small brownish beetle, with rough wing-cases, quite hard, so that it requires considerable pressure to crush it, which cuts scars in the young fruit, laying the egg in the puncture. This egg hatches to the "worm" which is so often found in peaches and plums.

Life History and Habits.—The adult insects appear in very early spring, about the time that the leaves on the peach and plum trees expand. They feed to some extent on the leaves. About the time the blossoms fall from the fruits they begin to deposit the eggs. A scar, usually in the shape of a crescent, is cut in the flesh of the young fruit, and in front of this crescent a hole is punctured. The egg is then laid in this hole. The adult beetles die shortly after. The egg hatches to a small white grub which bores directly through the flesh of the peach to the pit, where it feeds until it reaches maturity. This causes the peach to be soft, and often rot and fall before ripening. When the grub is fully grown it leaves the fruit and to the adult beetle, which again provides for the succeeding generation and dies.

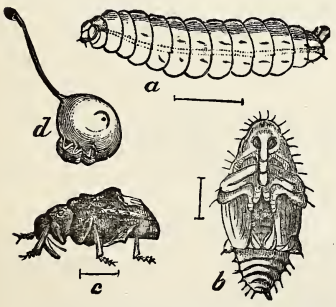


FIG. 6.—Plum Curculio. *a*, grub; *b*, pupa; *c*, adult beetle; *d*, adult on young fruit, showing the scar made by it.

(After Riley. Missouri Report.)

It seems that in this State the adult beetles pass the winter in sheltered places in woods, probably under bark. Trees standing near wood lands seem to be attacked first in the spring and the injuries seem to be more severe than on those further into the orchard which are more removed from the woods. This seems to be the universal experience in the large commercial orchards at Southern Pines.

This insect, with the Peach-borer and San Jose Scale, are the three most serious insect enemies of the peach in this State, and as Curculio and Borer are present in all orchards, we are inclined to place them in the first place so far as their damage in the State as a whole is concerned. But in those orchards where the scale has secured a foot-hold, we believe that it is even more destructive, as the neglect of one or two years (in a young orchard especially) means a loss of many trees.

Like many other insects, the adult beetles of the curculio have the habit of dropping quickly to the ground and remaining motionless ("playing 'possum") when they are disturbed, and this habit is made use of in combatting them.

Remedies.—Jarring the adult beetles from the trees into sheets is the best method yet discovered for the control of these beetles on the peach. After being thus collected the beetles are crushed with the fingers, burned or killed by pouring into a pan of kerosene or similar material.

The peach-growers at Southern Pines have developed this practice to a fine art, and other growers who will follow the same method will surely find it profitable. Two men are engaged in the operation. Each is provided with a frame upon which is stretched a sheet, the whole forming a half circle. This is made large enough so that two of them placed together will cover the entire space under a tree, and the frames are hung by straps from the shoulders of the men. The men walk along the row of trees on opposite sides, bringing the frames together under each tree as they go, and giving it a few smart blows with a heavy stick which is wrapped with an old sack so as not to bruise the bark. After jarring from one to twenty-five trees in this way they stop, lower the frames to the ground and crush the beetles with the fingers. The insects are naturally rather sluggish and do not fly readily when jarred from the trees, but crawl slowly about, or lie still on the sheets. They are more active, however, later in the day and for this reason it is best to do this work in early morning. The best growers begin the work by six or seven in the morning (as soon as the hands come) and stop at ten or eleven. Each tree should be jarred at least three times each week from the time the fruit "sets" until it is half-grown.

Special Note.—There will be many hundreds of insects jarred from the trees which are harmless or beneficial. Of course it is only desired to kill the beetles that actually do the damage, therefore every grower should be familiar with this pest. A study of the figure will aid in recognizing it. Fruit-growers should also observe closely and see if they can detect the beetle in the act of scarring the fruit, so that they may know the culprit at first hand.

There is another important point to remember. The egg of the curculio hatches into a *grub* and not into a small beetle. When the grub finally matures to the beetle it is full-grown when it comes out as a beetle. There is, therefore, no such thing as "young curculio beetles, which are smaller than the grown ones," as some seem to think. All of the curculio beetles are approximately the same size and of exactly the same shape and appearance. Any other beetles which may be jarred from the trees are of other species, which need not concern us.

BEES.

(Apis mellifera, Linn, and others.)

Bees have been twice reported to us as destroying the ripening fruit of peaches. There is no doubt that they do considerable damage in this way, but as a usual thing their attacks are more frequent on over-ripe fruit. They are seldom to be regarded as pests when the fruit is picked and shipped promptly when in shipping condition. It is, therefore, more often complained of in family orchards, where the fruit is purposely allowed to become as ripe as possible before picking.

Remedies.—The remedies to be used in this case must be purely mechanical for the bees are valuable property to their owners and so should not be destroyed. They are also very efficient in producing fruit by carrying the pollen from one flower to another, and thus probably repay many fold for all that they destroy.

Valuable trees might be covered with cheap mosquito-netting when the fruit begins to ripen. Also the fruit may be picked before it becomes fully ripe and kept indoors to mellow. A further suggestion is that some kind of tree or flowers might be planted near the hives or the orchard which would be especially attractive to the bees at the time the fruit is ripening, so as to induce them to leave the fruit alone.

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d. INSECTS ATTACKING THE PERSIMMON.

1. Attacking the Trunk or Branches.

THE TWIG-GIRDLER.

(Oncideres cingulata, Say.)

As the cultivation of the persimmon becomes more extended the work of this insect will probably become more noticeable and attract attention. At present no reports of damage by it have been received, but its work has often been noted on our common wild persimmon trees.

Description.—A grayish beetle with antennæ as long as the body, which gnaws around the twig so as to girdle it and cause it to drop easily.

Life History and Habits.—The injury done by this insect is incidental to egg-laying. The female deposits her egg in a little hole in the bark and then gnaws around the twig at a place *below* where the egg is laid. This cuts off the circulation of the sap and causes the twig to wilt and die. The grub which hatches from the egg burrows within the twig and feeds upon the drying wood and fermenting sap. When a heavy wind or storm breaks off the twig the grub falls to the ground with it. There it completes its growth and transforms to the *pupa,* all the time remaining within the twig. The pupa develops to the adult beetle, which gnaws its way out of the twig and escapes, when it proceeds to provide for the next generation.

Remedies.—A very simple and effective means of keeping this insect in control will be to gather and burn the fallen twigs so as to kill the developed insects within them.

2. Attacking the Leaves.

The fall web-worm (fig. 7).
(*Hyphantria cunea, Drury.*)

This insect is quite fully described in Bulletin No. 183, under the head of "Insects Attacking the Pear."

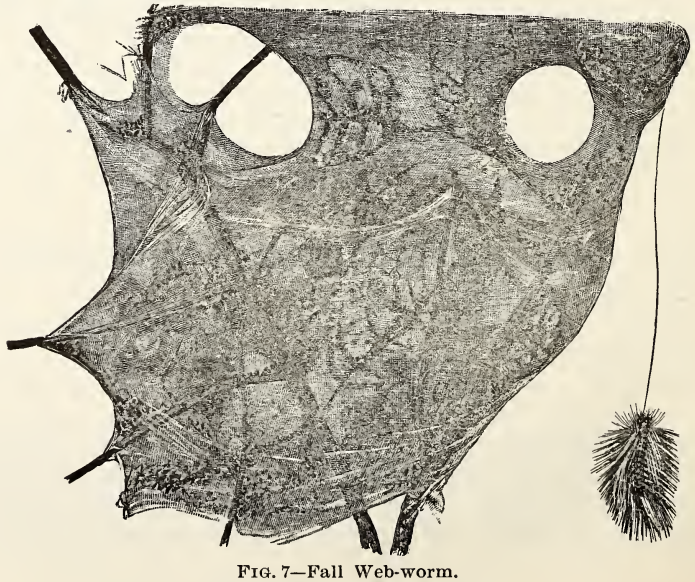

Fig. 7—Fall Web-worm.
(After Howard, U. S. Dept. Agr.)

Remedies.—At any time that this pest should become destructive the nests may easily be cut out and burned with their occupants. As these caterpillars do not leave the nest to feed, at any time that the nests are gathered the insects will be in them. But when about grown the caterpillars desert the nest, therefore the nests should be gathered and burned without undue delay after they make their appearance.

A spraying with Paris green in water at the rate of 1 ounce of green to 10 gallons of water would also be effective, especial attention being paid to the leaves closest to the nests.

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e. INSECTS ATTACKING THE PLUM.

1. Attacking the Branches.

THE FRUIT BARK-BEETLE (fig. 1).

(Scolytus rugulosus, Ratz.)

This insect has already been sufficiently described on pages 5 and 10 as an enemy of the peach. The same remarks there made will apply here, both with regard to its habits and as to remedies to be used.

LECANIUM—SCALE-INSECTS.

There is at least one species of Lecanium that attacks the plum in this State. This species is probably different from that described on page 11, but all the remarks there made as to remedies may be followed when the plum becomes likewise infested.

THE SAN JOSE SCALE (fig. 5).

(Aspidiotus perniciosus, Comstock.)

This famous pest has been very fully discussed as an enemy of the peach, to which tree it is, if possible, even more destructive than to the plum. The discussion will be found on pages 12-16. We have found, however, that the Wild-goose Plum is apparently not injured by the scale, which is worthy of note.

Remedies.—The remedies as recommended for the peach may be likewise applied to the plum, using the same precautions.

2. Attacking the Leaves.

THE BLACK PEACH APHIS.

(Aphis prunicola, Kalt.)

This insect, which is discussed on page 16 as an enemy of the

peach, is not infrequently also found on the young leaves of the plum, where it may do serious injury.

Remedies.—The remedial treatment suggested on page 17 will be followed when the insect attacks the plum.

LEAF-CHAFERS—various species.

There are various species of beetles which belong to the group of Leaf-chafers, which are liable to appear in great numbers at times, especially in the evenings, and devour the foliage. This occurs as soon as the leaves come out, for the beetles become mature at that season. We have had report of such injury in March, from Moore county, in which case the insect responsible was *Anomala undulata.* Various beetles of the genera *Anomala* and *Lachnosterna* are liable to do this injury.

Remedies.—If the grower makes a practice of spraying in the spring with Bordeaux Mixture and Paris green these beetles will be killed when they attack the tree, even though they may sometimes be present in such numbers as to defoliate the tree in spite of that protection. If they be detected as soon as they begin to swarm around the tree they may be combatted by immediately bringing out the spray pump and spraying the tree with Paris green and water at the rate of one ounce of green to eight gallons of water. This work should be done the very hour that the beetles are noticed damaging the trees—if they are present in sufficient numbers to do serious injury.

CATERPILLARS.

There are only a few species of caterpillars which do serious damage by eating the leaves of the plum. These caterpillars of course hatch from eggs that are laid by butterflies or moths (mostly by the latter), and they finally develop to that stage.

Orchards that are sprayed in the spring when the leaves are first expanding, with the Bordeaux Mixture and Paris green, are not troubled by these caterpillars. If they should at any time become numerous enough to be serious, they may be killed by spraying the trees with Paris green and water at the rate of one ounce of green to ten gallons of water.

3. Attacking the Fruit.

THE PEACH AND PLUM CURCULIO (fig. 6).
(*Conotrechellus nenuphar, Herbst.*)

This pest has been quite fully discussed as a pest of the peach on page 17. All the points there brought out will apply equally well when the insect attacks the plum, including the remedies suggested.

II. Fungus Enemies.

By F. L. STEVENS, Biologist.

a. FUNGUS DISEASES OF THE PEACH.

THE RUST.

(Puccinia.)

A true rust exists parasitically upon the peach and its relatives, the plum and cherry. (See Fig. 53, Bull. 92, of the North Carolina Experiment Station.) While more common upon the plum, it very frequently does damage to the peach, in some cases being so serious as to cause almost complete defoliation.

This malady will be recognized by the presence of small, round, dusty spots on the lower surface of the leaves and on the young shoots, while in the immediate region of these pustules the tissue, seen from above, often turns to a reddish or reddish-yellow color. It is in these pustules that the spores are borne, the mycelium of the rust fungus running through the tissue between the two surfaces of the leaf.

Treatment.—Evidently no treatment can reach the mycelium of the fungus without doing damage to the leaf itself. Reliance, therefore, must be placed in prevention. It is probable that enough spraying of the tree, such as is recommended for the peach curl and the mold, will to a great extent lessen the effect of the attack of the rust, inasmuch as the spores that winter over on the tender twigs and upon the bark of the tree will be thus killed or their germination inhibited.

THE MILDEW.

(Podosphaeria.)

There is a mildew on the peach very similar to the powdery mildew of the grape, cherry, lilac, and rose. It sometimes becomes so abundant as to almost completely ruin the crop, attacking the leaf and twig. When on the fruit, it appears first while the peach is small, causing irregular grayish blotches. These enlarge, and cracking often results. On these patches the summer spores, which serve to spread the disease to new tissues, are produced in great abundance. Some of these spores pass the winter on the surface of the bark, there awaiting to accomplish the spring infection.

Treatment.—The winter treatments recommended for both the peach curl and the brown rot, or mold, will be effective in killing these wintering spores, and will thus largely diminish the injury from this pest.

THE STEM BLIGHT.

(Phoma.)

Sometimes twigs die from the attack of a fungus on the bark. The fungus fructifies in minute pimples, which are filled with spores. The disease may be readily recognized by the dead bark thickly infested with small pimples. Burning of the diseased branches will prevent the spread of the pest.

THE CURL.

(Exoascus.)

This disease is distributed throughout the peach-producing region, being particularly abundant in the more moist localities. It has been estimated that the annual loss caused by it amounts to approximately three million dollars in the United States.

FIG. 11—The Peach Curl.

The disease is due to a fungus which grows in the leaves, causing the peculiar malformation which justly gives rise to the popular name of *curl*. This fungus destroys the utility of the leaf as a

starch-producing organ, and eventually causes defoliation, and thus direct loss to the trees. This loss may be manifest in two ways: First, by the present effect upon the vitality and vigor of the tree, and immediate injury to the crop; second, by a weakening of the tree in succeeding years, due to the lack of full nourishment during the period of attack. The injury in the present year, manifest by a loss in productiveness, is obvious to the grower. The injury in succeeding years, often fully as great, is often overlooked, or is not attributed to its true cause.

It was formerly thought that the mycelium of this fungus persisted in the twigs over winter, and thus lurked ready to infect the new leaves as they began to develop. It has, however, been proved that nearly all spring infection is due to spores which remain on the bark of the trees and not to perennial mycelium.

Treatment.—The mode of attack, then, in the prevention of the disorder is, obviously, to kill these spores by winter spraying. For this purpose the Bordeaux mixture, or a simple copper sulphate solution, is efficient. In many ways the Bordeaux is more satisfactory than the copper sulphate solution. It does not have a strong corrosive action upon the pump. It is easily seen upon the trees, and consequently it is not difficult to determine when a thorough application has been made. There is probably little choice between these two solutions on the ground of efficiency. The spraying should be made from one to three weeks before the buds open in the spring, and thoroughness is the chief point desired. Spraying should be done in dry calm weather, during the middle of the day, in order to avoid dew or frost upon the limbs.

Mr. Newton Pierce, in Bulletin 20 of the Division of Vegetable Physiology and Pathology, states as an experience in California, that in the treatment of the peach curl, from 95 to 98 per cent of the spring foliage was saved by spraying. A net gain of 600 per cent in the foliage over that retained by adjoining unsprayed trees resulted in the case of several different sprayings. The Bordeaux mixture, when applied to the dormant tree, increased the weight and starch-producing power of the leaves, and the sprayed trees showed a great gain over the unsprayed in the number and quality of the fruit buds they produced for the following year, the gain in the number of spur buds being over one hundred per cent in some cases. The lower limbs of sprayed trees showed a marked gain over those of unsprayed trees as compared with the upper limbs in both the number of the fruit buds and lateral shoots they produced. The sprayed tree also produces more vigorous growth of new wood, the wood to produce the crop for next year. Thus, in one experiment the spring growth of the unsprayed tree averaged 7.85 inches; on the sprayed trees it was 24.75 inches. The importance of this is obvious.

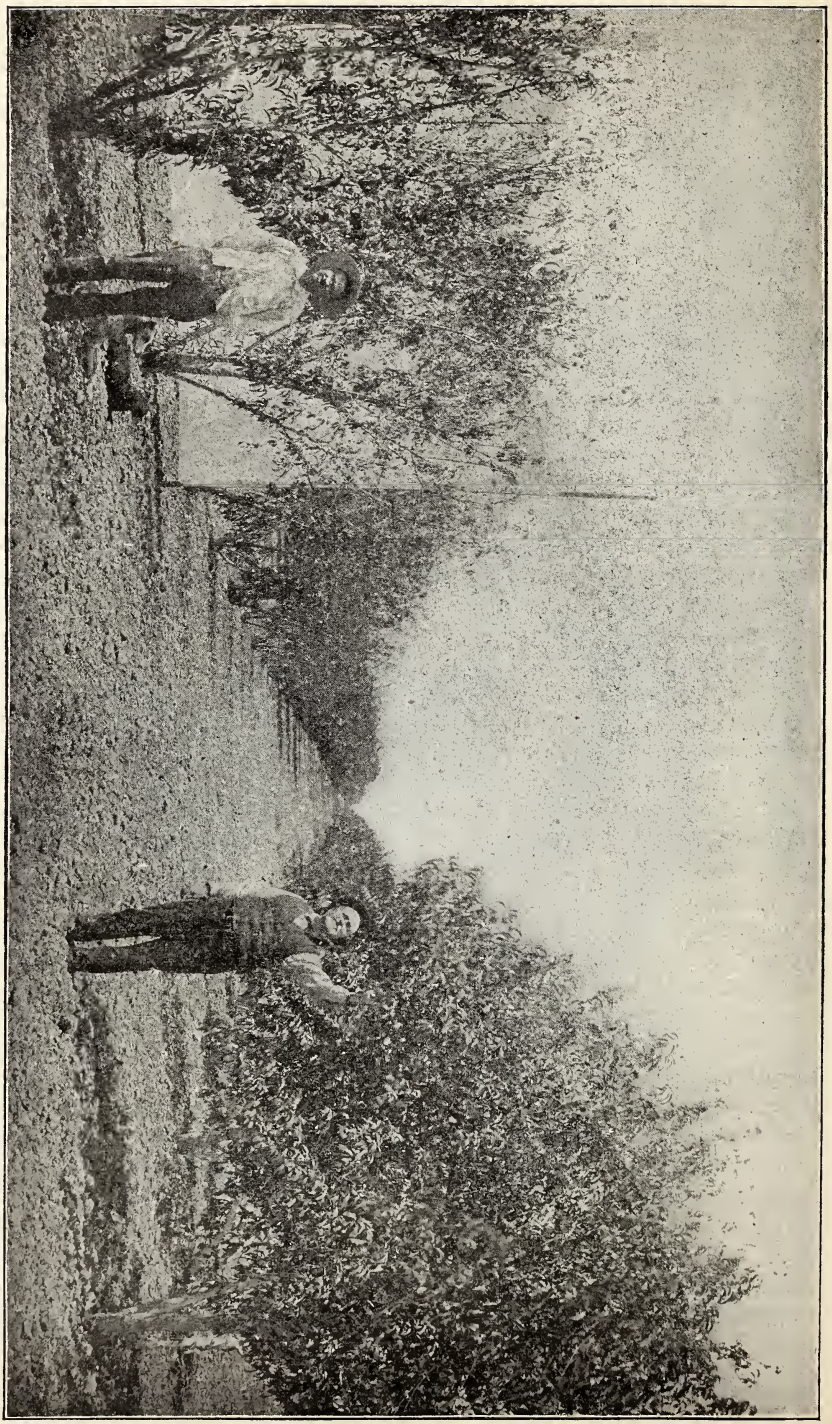

FIG. 12—Treated and untreated Crawford's Late Trees. (From Pierce, U. S. Department of Agriculture.)

The average value of fruit per tree in rows treated with the most effective Bordeaux mixture ranged as high as $6.20 above that in adjoining untreated rows, or the equivalent of a net gain of $427.80 per acre where trees are planted 25 by 25 feet. Over *one thousand* per cent net gain in the fruit set has resulted in the use of some of the more effective sprays.,

The trees should be sprayed each season, since the experiments prove that treatment one season will not prevent the disease the following year. Spraying should be done, even though the trees are not expected to bear, since the loss of the crop of leaves is shown to be as great a drain upon the trees as is the maturing of one-half to two-thirds of a crop of fruit.

All peach growers should apply to the Department of Agriculture for Bull. 20 of the Division of Vegetable Physiology and Pathology, which give a full discussion of this subject.

THE CROWN GALL.

(Dendrophagus.)

There is a malady of the peach, plum and almond trees which manifests itself by the production of conspicuous galls at the crown of the tree, while the general health of the tree and its productiveness becomes seriously affected. Very similar abnormal growths and symptoms likewise occur on numerous other trees: namely, the apple, pear, English walnut, grape, raspberry, blackberry, cherry, poplar and chestnut, as well as upon the apricot and prune, which are close relatives of the peach and plum already mentioned. Experimental evidence seems to indicate that the gall of the peach, plum, apricot, almond and prune are identical. Whether the disease upon the other trees mentioned is really the same or merely closely related, is uncertain, although the experiments so far made seem to indicate the non-identity of the diseases. On account of their similarity, however, they have all been grouped together in general writing, most commonly under the name of "crown gall," although other names, such as the "black knot," "root knot," "root galls," and "stem and root tumors" have been applied.

As the disease is of very wide distribution, it has been written about extensively and in widely separated regions, and much speculation has been indulged in as to its real nature. Several writers have expressed themselves as believing that the disease can be conveyed from one tree to another, while other writers express precisely the contrary view. Only very recently was exact knowledge obtained through the careful investigations of Mr. J. W. Toumey, then of the Arizona Experiment Station. It is from his bulletin that the present account is largely drawn.

The disease is prevalent in twenty-two States, including such

distant ones as California, Texas, Florida, New Jersey and Michigan. It is presumably present wherever susceptible plants are raised. Since it is of such wide distribution, and numbers among its hosts so many economic plants its damage is very great, although the injury is frequently overlooked, since the part attacked is underground and beyond mere casual observation. Many trees die or live unprofitable lives owing to attacks of the crown gall, without the owner recognizing the cause of the malady.

Mr. Toumey states that a conservative estimate would place the loss in Arizona in one orchard alone as high as ten thousand dollars,

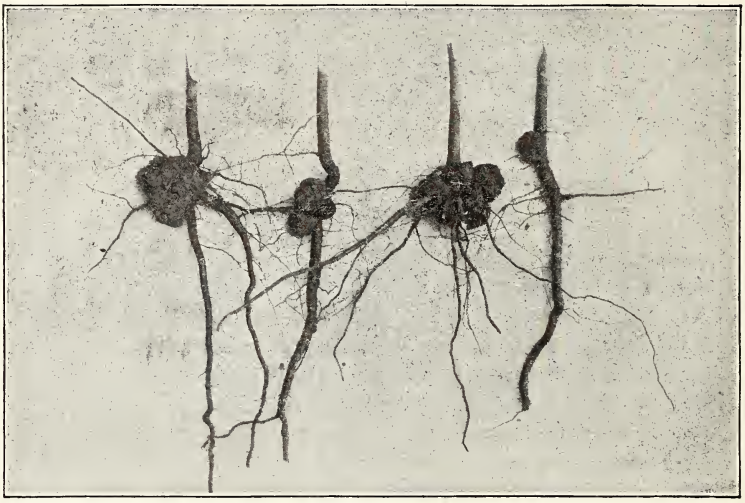

FIG. 13—Crown Gall.

and he considers that the loss to fruit growers in Arizona lies between $40,000 and $75,000 annually. Selby, in Ohio, states that in personal inspection of bundles of trees, he found in a lot of four hundred as many as twenty-four diseased trees, that is six per cent. One orchard in Lawrence County, containing 100 trees, purchased in New York, was grubbed out at seven years of age without having borne a single profitable crop. These trees were badly affected when delivered, and were nearly all diseased at the time of removal. One lot consisting of 1,500 trees, purchased in 1895, showed upon examination in 1897 that about 50 per cent were affected with the crown gall. The trees do not necessarily die, but they do worse, they live year after year and encumber the ground without returning profit.

For an accurate recognition of the disease the following description, translated by Mr. Toumey from Sorauer, is given: "The

swellings appear generally at the crown of the roots of young trees, the enlargements having the size of hazelnuts or walnuts. In older specimens they may attain the size of one's fist. When they appear upon nursery stock, they are usually limited to the crown, but occasionally are found deeper in the earth, or even upon slender one-year-old roots. The color of the gall is similar in its younger stages to that of the sound root. Later a darker color appears, in consequence of a deposit of dead matter, which forms the bark of the gall. If one examines the galls occurring upon the smaller roots, it will be seen that they are generally located upon one side of the root body. They have a softer tissue than the root, but their color within is normal. The large galls are a series of hemispherical growths, superposed upon each other, so that the surface has an irregular or warty appearance. In the spring the more prominent of these elevations have a light-brown appearance and a perfectly herbaceous consistency. In cross sections the galls show an irregular fibrous mass."

As early as 1895, Dr. Halstead, by planting peach pits in soil with minced peach galls found that such seedlings were more badly infested than seedlings grown in soil devoid of the minced gall.

Selby, by a similar experiment, arrives at the same result. More recently Mr. Toumey has proved conclusively that the gall may be inoculated from tree to tree. In one of his experiments, he made inoculations on 20 seedlings, and in every case bad galls developed at the place where the incisions were made. Further than this, he has proved definitely that the disease is due to a fungus which grows within the cells, causing hypertrophy of the tissue. The fungus is somewhat similar in its parasitic habits to that fungus which causes the club-root of the cabbage. It grows in the tissue and eventually fructifies, producing spores which serve to spread the disease.

That the disease does naturally spread from tree to tree is only too evident from field observation. Mr. Toumey mentions one orchard in Glendale where a small per cent of the trees had galls upon them when planted, yet at the expiration of eight years less than one per cent remained unaffected. The spores from the old decaying galls are conveyed to the soil and thence to the new tissue, the spread being effected largely by cultivating tools. Any break in the bark near the ground gives better foothold for the establishment of the enemy.

Treatment.—Diseased trees should be taken up and burned. A gall either above or below the surface of the ground is a constant menace to healthy trees. Little can be done in the way of soil treatment to prevent the spread of the disease. The best procedure is to examine the orchard yearly, cut the galls from the crown, and cover the wounds with a blue-stone-copperas-lime paste, which will prevent re-infection.

Of course the greatest care should be exercised that no diseased trees be introduced into your orchard, and that you purchase only from nurseries which are free from the crown gall. If you receive a bundle having any galled trees, reject the whole lot, as those which do not show the disease may be already inoculated and in an incipient state.

FROSTY MILDEW.

(Cercospora.)

In damp, shaded localities a disease sometimes occurs on the peach, producing small, pale yellowish leaf spots. These show on the underside a delicate frost-like appearance, due to the growth of spore-bearing hyphae. It is not usually seriously abundant, and the treatments recommended for the other diseases will suffice to also hold this disease in check.

THE FRUIT SCAB OR THE BLACK SPOT.

(*Cladosporium.*)

This very common disease may consist of isolated sooty black specks, or of black specks so numerous as to coalesce into large blotches, which may sometimes cover as much as one-third or one-half of the peach. The side which is attacked will be dwarfed, often cracked, and the flesh adjacent to the diseased peaches remains bitter and green, even after the normal portions are ripe.

This spot is due to the growth of a fungus which probably winters on the branches of the tree. Winter spraying, such as is recommended for the peach curl, will kill these winter spores and reduce summer infection.

The disease develops to a more serious extent during rainy seasons, sometimes doing damage equal to 70 per cent of the value of the crop. Selby, of Ohio, estimates the loss in one crop that came under his observation at from 20 to 50 per cent. The scab, when bad upon the tree one year, is very liable to appear upon the same tree during following years. It is therefore advisable to spray infested trees, since the condition points to an almost certain reinfection in the following year.

THE PUSTULAR SPOT.

(*Helminthosporium.*)

This is a comparatively new disease, and is worthy of note from the fact that its spread should be recorded. The diseased peaches are described by Selby as "Badly disfigured, having numerous pimply red spots with light-brown centers." The peach, seen in an earlier condition of the disease, shows small rusty-brown spots upon

the upper side. These increase in size and develop light-brown centers about one twenty-fifth to one twelfth of an inch in diameter. Upon yellow varieties the pustule is commonly lacking, there being cut a light-brown center with a red border.

As the fungus which causes this spot rests purely upon the surface, development is prevented by spraying. Selby reduced the injury from 16 per cent to 1 per cent by using three applications of the Bordeaux mixture.

SHOT HOLE.

Many times in the peach orchard leaves are seen, more or less abundant, which appear as though perforated by shot. This is caused by the dropping out of a small area of the leaf tissue, owing to attack by fungi. Various fungi have been reported as capable of causing this appearance. Likewise poisoning by the use of Bordeaux mixture carrying too much copperas will cause this effect. The remedies already given are sufficient for this trouble.

THE BROWN ROT OR MOLD.

(*Monilia.*)

No other disease is probably so destructive to peaches, plums and cherries as is the brown rot, which attacks the fruits as they mature, turning them brownish in color, soft in texture, and useless in quality.

While this disease is most conspicuous in its damage to the fruits above mentioned, it also occurs to a greater or less extent on apples, pears and quinces. Aside from being present on the mature fruit, it also attacks the flowers and twigs. Its characteristic appearance on the fruit enables one to recognize it easily. It first appears as a small circular decayed spot. This spot rapidly enlarges until it embraces the whole fruit, at the same time shrinking it slightly. The diseased areas are brownish in color. As the decay advances, small tufts of threads appear in the center of the original spot, and rapidly spread, until the whole fruit becomes involved.

If the fruit hang in clusters, adjacent fruits will begin to decay at the points of contact, and the disease will spread from fruit to fruit until the whole cluster is lost. Nor does the damage end here. Fruit after it is picked may succumb to the attack, and peaches that were apparently sound at picking may be seriously damaged when they reach the end of their journey to market. Thus the loss falls upon both the grower, dealer and consumer. The advance of the decay in the peach is so rapid that infection to-day may mean a totally unsalable peach two days hence.

Peaches diseased on the tree may fall to the ground, or persist on the tree where they shrivel up and remain hanging over winter. They

then constitute the "mummy" peaches so familiar in infected orchards.

Upon the blossom the disease becomes first evident as a slight brownish discoloration which, as in the case of the fruit, spreads rapidly, causing the flower to wither and eventually fall off as a rotten mass, carrying contagion to everything in its path. From the flower the rot may spread to adjacent twigs, through the flower stalk. Infection of the twigs may also occur directly from diseased fruit. From repeated observations it seems probable that the branches can not be infected through their unbroken skin, or if so only rarely. Dr. Smith states that the examination of hundreds of twigs in all stages of disease showed that every one was associated with blighted and persistent flowers. In the majority of cases the entire twig was killed.

FIG. 14—Peaches molding on tree.

FIG. 15—Mummy peaches hanging on tree in winter.

Estimates as to the damage caused by this disease are unnecessary, since a glance into any peach basket on the market will convince any one of its great extent. We may mention, however, that its in-

roads are so serious that many of the peach and plum growers in this State will be obliged to secure a remedy for this pest or abandon the industry.

As with many other plant diseases, the cause is a microscopic fungus, which grows within the tissue of the fruit or twig, producing chemicals there which dissolve and discolor the tissue. After the fungous threads grow until they have partially exhausted the nourishment in the tissue, they send minute branches out through the surface, and produce the small tufts which are characteristic of the latest stages of the mold. These tufts bear the spores or reproductive organs in enormous quantity, and every breath of wind or splashing drop of water throws spores into the air to be blown to new fields of destruction.

Many people are inclined to regard the rot as inevitable, and as representing the normal condition of things. This rot, however, is due to a fungus, and if the spores of this fungus can be kept off, the rot can not develop. It is, however, to be noted that damp, "muggy" weather is just the kind which is most favorable to the rapid development and growth of the fungus. Cold storage or poisonous chemicals may prevent or retard this growth. Years in which there is full fruitage, accompanied by damp, warm weather, are almost certain to bring a severe attack of the rot; but it must be remembered that it is not the weather which directly causes the rot, but that it is the fungus which causes the rot, and the weather gives the proper condition for the development of the fungus. Otherwise there would be no hope, since we can not control the weather.

Experiments have been made in many States for the prevention of this most serious enemy of the drupaceous fruits. Some of the experiments have given the most flattering results, while others have been attended with almost total failure. It must be said that as yet we can not be confident of totally preventing the damage, yet we have great hope that we can largely control it, and that the near future will see decided advances in the methods of treatment.

The accompanying illustrations, taken from a South Carolina Experiment Station bulletin, show the results obtained there. These results were gotten by the use of Bordeaux mixture, spraying first just before the buds open, second when the fruit is well set, third about two weeks later and fourth when the fruit begins to color. In the first spraying they advise the use of Bordeaux mixture made of six pounds of copper sulphate, six pounds of lime, and 45 gallons of water. In any applications later than the first, the copper sulphate is reduced to $2\frac{1}{2}$ pounds and the lime to 5 pounds.

They estimate the cost of four applications at from 12 to 13 cents per tree. At the Delaware Experiment Station the cost of six ap-

plications is estimated at 12 cents per tree, including labor and materials, while in Georgia it is estimated that one can spray four times for six cents. The tree, of course, should never be sprayed while in bloom, since this would destroy the power of fruiting.

Thoroughness should be the chief point. Every twig and leaf should be wet with the spray, yet it should not be so wet as to drip. If the orchard is sprayed one day, and the rain washes this spraying off, spray again as soon as possible. A thin coating of Bordeaux mixture should be kept on the fruit until the ripening period, and if washed off it must be replaced. Rainy weather is the most favorable weather to the development of the fungus, therefore spraying should be neglected least of all at this time.

All agree that every diseased piece of tissue in the orchard may carry over spores to the following year, therefore you should go through your orchard and remove and burn all dead twigs and decayed fruits as soon as possible. After burning all trash, a winter spraying to destroy all spores wintering on the bark will pay. This application should consist of copper sulphate, 1 pound, and water, 25 gallons, or strong Bordeaux mixture may be used. Apply this spray from one to three weeks before the buds open. This will also prevent the peach curl. The copper sulphate of the Bordeaux mixture is injurious to peach foliage, but the results at the South Carolina Experiment Station seems to indicate that 2½ pounds may be used with safety in forty-five gallons of water with five pounds of lime.

The benefits of spraying reach much farther than to merely increase the harvest from the tree, since spraying the tree increases very materially the keeping quality of the fruit. This was illustrated in a test made by the Georgia Experiment Station, as follows:

"July 5, a basket of apparently perfectly sound peaches was gathered from each of two trees of Heusted's No. 53, one tree having received two applications of Bordeaux mixture, the other tree being unsprayed. These two baskets were placed side by side on a shelf in the laboratory. Forty-one hours later it was determined by count that three-fourths of the peaches from the unsprayed tree were more or less rotten, while the fruit from the sprayed tree was perfect. July 9, all of the peaches from the unsprayed tree quite rotten, and sprayed fruit perfect. July 10, sprayed peaches still perfect.

"On same day, July 5, a basket of Carman peaches was gathered from each of a sprayed and unsprayed tree. July 7, about fifty per cent of peaches from unsprayed tree rotting, while fruit from sprayed spores to the following year, therefore you should go through your tree perfect. July 10, all peaches from unsprayed tree are quite rotten and sprayed fruit with three peaches showing rot. July 12, peaches from sprayed trees now rather badly rotten.

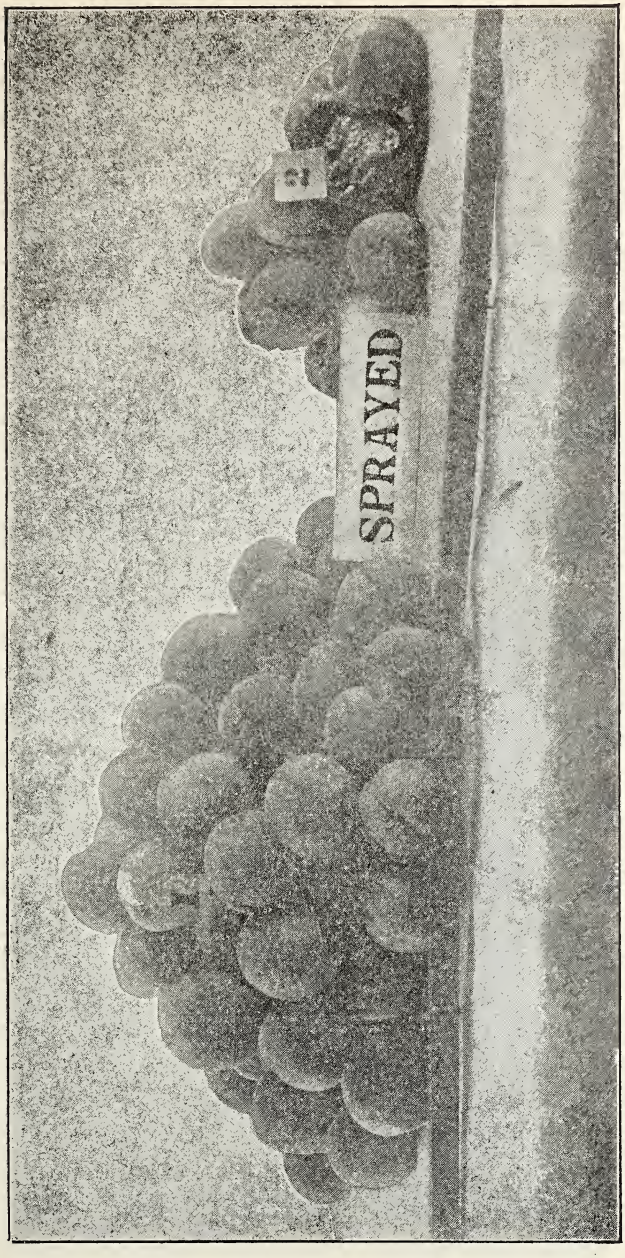

FIG. 16.—Fruit from sprayed trees. (1) Sound fruit. (2) Rotten fruit.

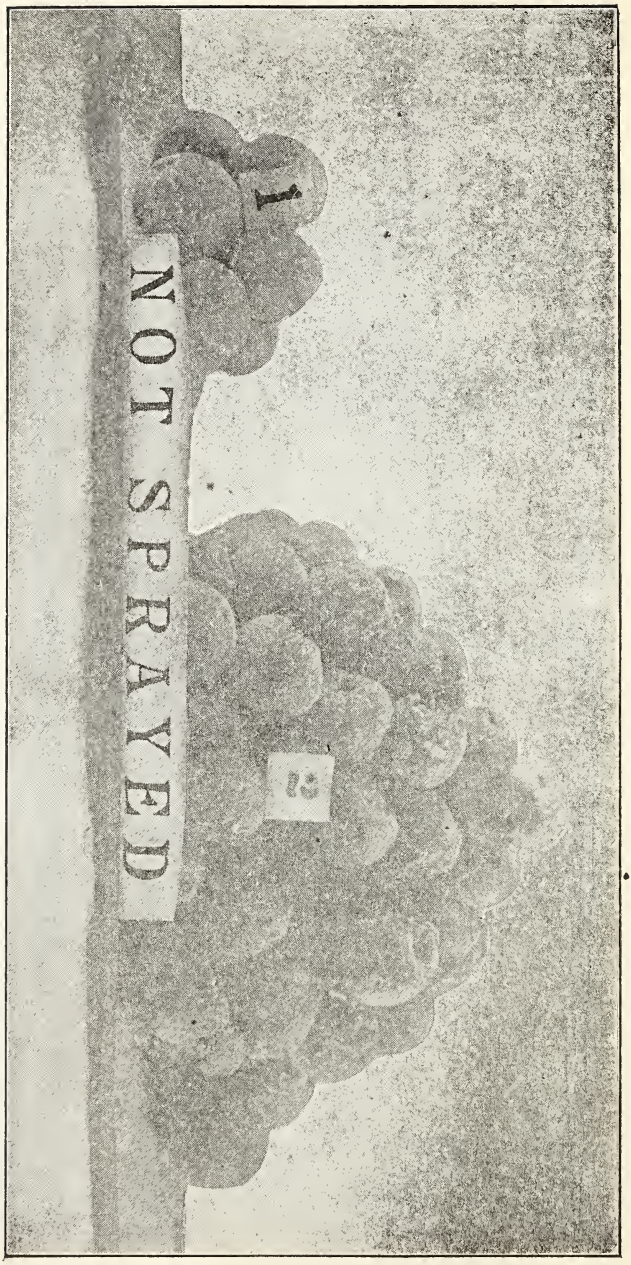

FIG. 17.—Fruit from a tree not sprayed. (1) Sound fruit. (2) Rotten fruit.)

"Practically the same test of keeping qualities of fruit from sprayed and unsprayed trees was made with early Michigan, Champion, Heusted's Extra Early (No. 16), and Heusted's No. 54, with the results that peaches from sprayed trees have kept from three to five days longer than peaches from unsprayed trees."

There is objection to applying the Bordeaux mixture after the peach begins to ripen, inasmuch as it may adhere and cause unsightly spots, which, while in reality perfectly harmless, injure the selling value of the fruit. To avoid this, various substitutes have been tried; foremost among these are two, namely, copper acetate (dibasic acetate of copper), and potassium sulphide. The results from some stations seem favorable to the use of these, while other experiments are not so promising. The final word regarding either of these substances can not yet be said. As a result of experiments the Georgia Experiment Station, recommends discontinuing the Bordeaux mixture after the fruit has begun to color, and substituting copper acetate, at the rate of six ounces of copper acetate to fifty gallons of water. Dissolve the copper acetate by stirring and apply with a spray pump. This substitution should be made three or four weeks before the peaches are to be picked. The California Experiment Station, with regard to the same mold on the olive, makes a similar recommendation. Dr. Sturgis, of the Connecticut Experiment Station, finds that the acetate of copper, in its ordinary form, that is the subacetate or verdegris, can not be used, since it injures the foliage, but that the normal copper acetate is harmless and is effective as a fungicide. The difficulty of securing this normal acetate, however, precludes its general use. Dr. Sturgis experimented with potassium sulphide, and found a solution of one pound to fifty gallons of water most favorable. He noted no injurious effect from this, and when the solution was used very thoroughly he found an increase of almost 20 per cent in the yield of perfect fruit.

Summing up the experience of all of the people who have sought to prevent the mold of the peach, the following recommendations are made:

1. Clean and burn all decayed fruit or diseased twigs.
2. Spray with a strong Bordeaux (5-5-50) or copper sulphate solution (1 pound to 18 gallons) before the buds expand.
3. Just before the blossoms open spray with a weaker Bordeaux mixture (2½-4-50 or 3-6-50). Repeat this treatment every two weeks, or as often as need be to keep a coating on the fruit until it begins to color.
4. After the fruit begins to color, substitute either potassium sulphide, 1 pound to 50 gallons of water, or the copper acetate, 6 ounces to 50 gallons of water.

The Peach Yellows and the Peach Rosette.

These two diseases of the peach, while excessively destructive in certain regions, are not yet known to occur to any dangerous extent in North Carolina. The statement is generally current that they do not exist here at all; yet there are rumors of their occurrence, which while yet not fully authenticated are still worthy of tentative acceptance. The peculiar fact that these diseases are present on both sides of the State—the Yellows on the north and the Rosette on the south, emphasizes the particular importance of being forewarned as to their nature and regarding the possibility of invasion, so that the peach-growers may stamp out any attack in its incipiency.

PEACH YELLOWS.

The peach yellows has been known in the United States something like one hundred years. It seems to have first spread from a centre, somewhere in the neighborhood of Philadelphia, and is now quite general through Pennsylvania, Maryland, Delaware, New Jersey, Massachusetts, Rhode Island, Connecticut, and through portions of New York, Michigan, Indiana, Ohio, Illinois, Northern Kentucky, West Virginia and Virginia. It is extending its frontier in every direction.

Fig. 8—An affected twig.

The disease is of unknown cause, but it has been absolutely and positively proved that it is contagious, that can be conveyed from tree to tree. *The tree must therefore be cut and burned.* Cut the trees and allowing them to lie in the orchard is as bad as leaving them standing. The roots, however, do not infect the soil, and a tree may be safely planted in the identical spot from which a diseased tree has been removed.

These facts should enable the peach growers of this State to completely eradicate the small amount of disease now here, and prevent its encroachment upon our land.

It is easy to recognize this disease, as it has marks which leave no uncertainty as to its identity. They are given in the words of Dr. Smith as follows:

"Prematurely ripe, red-spotted fruits, and premature unfolding of the leaf buds into slender, pale shoots, or into branched, broom-like growths, are the most characteristic symptoms of yellows. The time of ripening of premature fruits varies within wide limits; sometimes it precedes the normal ripening by only a few days, and at other times by several weeks. *The red spots occur in the flesh*

FIG 9—A peach affected with yellows, showing spots on the surface, also a sectional view showing the diseased interior.

as well as on the skin (see Fig. 9), making the peach more highly colored than is natural. The taste of the fruit is generally inferior and often insipid, mawkish or bitter. Often this premature ripening is the first symptom of yellows. The peaches are then of good size and quite showy, and occur on trees in full vigor, upon limbs bearing abundant green foliage and sometimes also other fruits which afterwards ripen normally.

Often during the first year of the disease this kind of fruit is restricted to certain limbs, or even to single twigs, which, however, do not differ in appearance from other limbs of the tree. The following year a larger part of the tree becomes affected, and finally the whole of it, the parts first attacked now showing additional symptoms, if they have not already done so. These symptoms are the development of the winter buds out of their proper season. Like the prematuring of the fruit, the date of this also varies within wide limits. The buds may push into shoots only a few days in advance of the proper time in the spring, or may begin to grow in early summer, soon after they are formed, and while the leaves on the parent stem are still bright green. This is a very common and characteristic symptom, and is especially noticeable in autumn when

the normal foliage has fallen. Usually under the influence of this disease feeble shoots also appear in considerable numbers on the trunk and main limbs. These arise from old resting buds, which are buried deep in the bark and wood, and remain dormant in healthy trees. Such shoots are sometimes unbranched and nearly colorless, but the majority are green and repeatedly branched, making a sort of broom-like, erect, pale-green, slender growth, filling the interior of the tree."

Treatment.—Any tree exhibiting these symptoms must be cut and burned. It is valueless, and its presence is a serious menace to the owner and to the State.

PEACH ROSETTE.

The peach rosette is Southern in distribution, being known principally in Georgia, South Carolina and Kansas. It may possibly encroach upon our State, and growers should be forewarned regarding its character. As to its nature, means of spreading, and means of prevention, precisely what has been said of the yellows applies. Its distinguishings characters are given by Prof. Smith as follows:

FIG. 10.—A single Peach Rosette.
(From Smith, U. S. Department of Agriculture.)

"Rosette clearly belongs to the same type of disease as yellows, but its first stages are more striking and its progress is much more rapid. It may first attack part of the tree and then the remainder, the same as the yellows, but it is more likely to appear at once on the whole tree, and generally in early spring. In trees attacked in this manner, all of the leaf buds grow into compact tufts or rosettes. These rosettes, though seldom more than two or three inches long, usually contain several hundred small leaves. One rosette is shown in Fig. 10. A tree thus attacked always dies during the following winter or autumn. When part of a tree is thus attacked, that part dies as

above described, and the remainder shows symptoms the next spring, to die in turn after about six months.

"The prevailing color of the foliage is yellowish green or olivaceous. The older leaves at the base of the tufts are largest and frequently grow to a length of several inches, but have inrolled margins and a peculiar stiff appearance, due to the fact that they are straighter than healthy leaves. These outer leaves turn yellow in early summer, and drop as readily as though it were autumn, while the inner leaves of the rosette are still green and delicate. The compact bunching of the leaves is very conspicuous, and makes the trees look quite unlike those affected by yellows. Where a tree is attacked in all parts it matures no fruit. In all the cases which have been noticed, the fruit borne by affected trees either shrivels while green and drops off, or else ripens naturally. No premature peaches have been seen in Georgia, except such as were due to the girdling of the trunk by borers.

"In the absence of premature, red-spotted fruit, in the severity of the disease from the outset, and in its rapid progress, it is quite unlike yellows, which is decidedly chronic, and the first slight symptoms of which usually occur in very green and thrifty trees, and are frequently overlooked the first season."

Treatment.—Cut and burn. No carelessness should be tolerated regarding either of these diseases, which have not yet gained foot-hold in the State, and which may be kept in complete subjugation by proper watchfulness and care.

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b. FUNGUS DISEASES OF THE PLUM.

THE PLUM SPOT.

(*Cladosporium.*)

The plum scab causes spotting of the fruit similar to the scab of peaches. "When plums begin to ripen or are just turning in color, small round patches not larger than a pin head make their appearance. They are pale greenish or grayish in color. These spots increase in size until in some cases they are half an inch across. They are usually round, with a border somewhat paler than the inside. In older specimens the patches are frequently confluent and of darker brown color. In very old specimens, especially in those where the fruit has undergone decomposition, the patches become black and uneven.

"An examination of the small grayish spots shows a nearly colorless mycelium creeping over the surface. In the darker portions of the large patches are septate hyphae."

This disease is very close kin to the scab of the peach, and it is unnecessary to discuss it separately here. Treatment the same as that recommended for the peach will apply in this case.

THE LEAF CURL.

(*Exoascus.*)

This disease is very similar to the peach curl, and seems completely amenable to treatment with the Bordeaux mixture. (See Peach Curl in this bulletin.)

THE LEAF SPOT.

(Cylindrosporium.)

The leaf-spot or shot-hole disease attacks plums and cherries, causing a portion of the leaf tissue to become discolored, the spot often bearing a red or purple border. If abundant, several spots may coalesce as they advance in maturity. The tissue involved dies, turns brown, and often drops from the leaf, leaving circular or ragged holes. This character gives rise to the common name, "shot-hole disease."

The attack is very insidious, and the disease often does much damage before its presence is really known. The chief injury is through defoliation, the leaves falling freely after the attack of the fungus. This defoliation checks the starch-producing power of the tree, and this in turn impairs the tree's general vigor and productiveness, even weakening the tree to such an extent that it can not withstand the winter.

The disease is especially injurious to nursery stock, as it may interfere with successful budding and grafting. The following recommendation in the way of treatment is made by the New York Experiment Station:

1. Apply the Bordeaux mixture about ten days after the blossoms fall.
2. About three weeks later repeat this treatment.
3. About four weeks later repeat again.

In one instance in the New York Station, "The treatment resulted in an average increase per tree of twenty-four and one-half pounds of marketable fruit, at an estimated cost of less than one cent per pound. The average yield per tree of picked fruit was increased 44 per cent, the marketable drops increased 8 per cent, and the waste was decreased 81 per cent. The total yield of marketable fruit as recorded in pounds was 45 per cent greater when the trees were sprayed than when they were not sprayed."

PLUM POCKETS.

(*Exoascus.*)

The name *plum pocket,* or *plum bladder,* arises from the curious hollow deformity of the plum, caused by the fungus *Exoascus.* The pulp of the fruit is replaced by a thin, puffed-up shell, and in the place of the seed merely a hollow cavity exists.

The disease appears soon after the flowers fall, and the affected fruits drop from the tree. The diseased fruits vary in size from one to two inches in length, and can be readily distinguished from the healthy fruit by their pale, yellow color. As they age, they become coated over on the outside with a fine powder. This powdery coating consists, in reality, of multitudes of spores produced by the fungus within, which has caused the malformation of the fruit. Later the pockets turn black and fall.

The disease is local in character, rarely attaining the prominence of an epidemic. A single tree in an orchard may bear the "pockets," sometimes every fruit on the tree being affected, while surrounding trees are normal. A tree once affected continues to bear pockets in succeeding years. Treatment may consist in cutting and burning affected branches or trees.

THE RUST.

(*Puccinia.*)

The rust of the plum is very closely allied to the rust of the peach, and the reader is referred to the article in this bulletin on the peach rust for information regarding this disease.

THE BLIGHT.

(*Bacillus.*)

The blight of the apple and pear have been discussed in bulletin No. 183.

A very similar blight is rarely known to affect the plum tree. Recently exceedingly careful studies have been made which make it almost certain that the disease of the plum and pear are identical. Germs or tissue taken from the diseased plum tree and inoculated into the pear promptly produced the familiar pear blight, and microscopic examination showed that the germs of both blights have the same appearance.

While the plum blight is exceedingly rare, it is important that fruit growers should know that the disease is identical with the pear blight, as this knowledge will of course help very materially in fighting the disease.

The remedy is the same as that recommended for the apple and pear, namely, to cut out and burn all affected branches. (See Bulletin 183, page 66.

THE PLUM YELLOWS.

(See peach in this bulletin.)

THE MOLD OR BROWN ROT.

(*Monilia.*)

(See peach in this bulletin.)

BLACK KNOT.

(Plowrightia.)

The black knot receives its name from the swollen black distortions on the branches. In its earliest conditions the knot is merely a swelling of the twig; as the swelling proceeds, the bark cracks, and from these cracks come forth fungus threads which cover the surface of the twigs, and eventually bear great quantities of spores. These spores, carried by the wind or water, reach the surface of other young shoots, and there originate new swellings. In a young condition, the galls are olivaceous, but as the season advances they become darker and eventually coal black. At the same time the texture changes from juicy to hard and brittle. It is in this hard brittle knot that another kind of spore, the winter spore, is borne. These serve also to spread the contagion, but at another time of the year. It will be seen that the fungus has two, and if the whole story were told it has more than two, methods of spreading from tree to tree, and consequently it is a very destructive pest. Moreover, it grows upon all kinds of plums and nearly all cherries, and is therefore very widely distributed.

Occasionally, when the swelling becomes old, insects take refuge in it, and for this reason some observers have thought that the insects cause the gall; this, however, is not true. The insects come only after the gall is formed. The fungus actually causes the gall.

When the disease extends all of the way around the twig, the supply of nourishment to more distant parts is seriously interfered with. If less than the whole of the circumference be involved, the damage, of course, is not so great, but it is even then great enough to very seriously impair the fruiting power of the tree. The knots may completely kill the tree in a year or two, or they may be only abundant enough to destroy the value of the tree.

It seems probable that the spores can cause infection only when they fall upon injured bark, that is, the fungus can not enter through perfectly healthy bark. One step towards lessening the disease is therefore to exercise all care to not bruise the tree.

Effective measures, however, must consist of pruning out and burning all black knots. If pruned out and left in the orchard, the fungus continues to grow, to produce spores, and to cause infection. The knots must be burned. Cutting out and burning diseased twigs, if followed thoroughly, will remove all danger. Experiments show that the Bordeaux mixture will very materially lessen the spread of the black knot, and while it might not pay to spray to prevent this disease, spraying in an orchard for other reasons will really lessen the danger from the black knot.

THE POWDERY MILDEW.

(*Podosphaeria.*)

(See cherry in this bulletin.)

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c. FUNGUS DISEASES OF THE CHERRY.

POWDERY MILDEW.

(*Podosphaeria.*)

The mildew described in another bulletin in connection with the diseases of the apple, sometimes does considerable damage to the plum and cherry, especially on nursery stock where the growth of the mildew prevents either the growth of the seedling or successful budding and grafting. This mildew is a fungus. In the summer it produces white spots on the surface of the leaves, and in these spots millions of spores develop. These spores are spread by wind and water, and carry the infection to neighboring trees. Another kind of spore is produced as fall approaches, to carry the disease over winter.

The fungus grows on the exterior of the leaf, but sends minute root-like suckers into the tissue to suck up nourishment. The affected patches are circular in outline, because they originate from a central infection and thence spread with equal rapidity in every direction. On old leaves the disease is not of great damage, but when the attack is made on young growing tips, or on young leaves, these delicate structures suffer greatly from the loss of the nourishment stolen from them.

Contrary to the nature of most fungi, these mildews live and grow best during fair, dry weather. A light rain which will spread the spores and furnish moisture enough to allow them to germinate, followed by a dry spell, best favors the growth of the fungus.

The fungus rests on the outside of the leaf, thus furnishing one of the few cases in which cure rather than prevention is possible, although of course the old adage is ever true. To hold this disease in check, the use of the Bordeaux mixture has proved very satisfactory. Apply it about every ten days during the early growing season, and more frequently if necessary to replace any poison washed off by the rain.

LEAF SPOT (*cylindrosporium*)—(see plum in this bulletin).

RUST (*puccinia*)—(see peach in this bulletin).

BLACK KNOT (*plowrightia*)—(see plum in this bulletin).

THE MOLD OR BROWN ROT.

(*Monilia.*)

The same fungus which produces such disastrous results upon

the peach also causes a mold or rot on the cherry. Inasmuch as the fungus is identical with that of the peach rot, its treatment is the same, and it is not necessary to discuss it further here. (See Peach in this bulletin.)

THE CURL.

(*Exoascus.*)

The cherry curl is due to a fungus closely related to that of the peach curl. The leaves become wrinkled before they are full size, and the spores are produced on the surface of the leaf, as they are in other "curls." The disease is not common in America. Should it become so, it can be held in check by pruning out the diseased twigs.

THE CHERRY SCAB.

(Cladosporium.)

(See scab of plum and peach in this bulletin.)

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d. FUNGUS DISEASES OF THE PERSIMMON AND FIG.

While several diseases are known to affect these fruits no particular attention has yet been given to them, owing to the slight commercial importance of the fruits in question in this State. Several of the diseases of the persimmon and fig are undoubtedly identical with similar diseases of the fruits mentioned in previous pages of this bulletin, and the treatments recommended here will probably prove useful with these fruits. Any persons suffering from injury by disease to the persimmon or fig are requested to send to the Experiment Station the diseased leaves, twigs or fruits, that a study of the same may be undertaken.

Bulletin No. 187. September, 1903.

NORTH CAROLINA

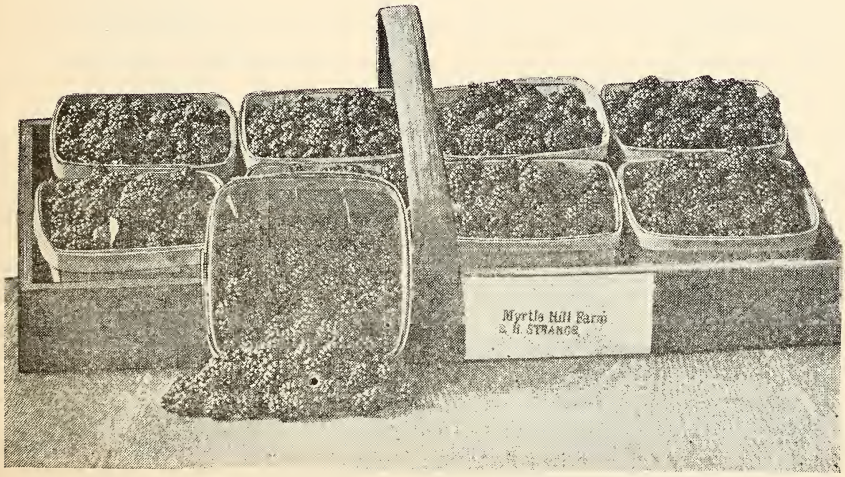
Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

GRAPES AND SMALL FRUITS.



DEWBERRIES.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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C. W. BURKETT ..... Agriculturist.
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J. S. JEFFREY ..... Poultryman.
B F. WALTON ..... Assistant in Field Experiments.
J C KENDALL ..... Assistant Dairy Husbandry.
A. F. BOWEN ..... Bursar.

The D rector's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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THE CULTURE OF GRAPES AND SMALL FRUITS.

By W. F. MASSEY, Horticulturist.

Introduction.

Before the days of the Experiment Stations and the study of means for combatting fungus diseases on cultivated plants, the Southern Horticulturists had almost despaired of growing the varieties of grapes cultivated in the North, because of the prevalence of mildew and rot in our climate.

If the Experiment Stations had done nothing else than to bring before the cultivators the use of the Bordeaux mixture and other remedies for fungus troubles they would have warranted all they have cost. Armed with the remedies or preventives of disease and the means for combatting insect attacks the culture of the Grape has attained great importance in the South, and we are no longer obliged to say as the late W. N. White said in the first edition of his "Gardening for the South," that it is useless to attempt to grow the Labrusca and Aestivalis species of grapes in the South, for we can grow them to as great perfection as they are grown in any section of the country, and can make as fine wine as is made anywhere, while we can put the ripe fruit into the Northern markets when they are bare of grapes from elsewhere.

Then, too, it is important that the grower for home use in the South should be acquainted with the best methods of culture and the same preventives of disease and insect attacks. It is for this class of growers that this bulletin is mainly intended, for the large growers are already well informed on the subject. Farmers as a class do not have fruits enough for their home use, while it is perfectly easy to have a full supply of healthful fruit, and if this bulletin will lead the farmers of the State to better supply themselves with grapes and small fruits, its mission will have been accomplished.

The Culture of Grapes.

Propagation of the Grape.

Grapes are commonly propagated from long cuttings set in the open ground in the fall. They are also grown from single-eye cuttings under glass and by layers, and inferior sorts can be changed at once into good ones by grafting the improved variety on the base of the inferior stem.

Most of our grapes which are here classed as "bunch" grapes belong to the botanical classes of Labrusca and Aestivalis, while others are the result of crossing these with the European Vinifera and other genera. Most of these are easily grown from long cuttings set in rows in the fall. Some, like the Delaware and Norton's Virginia do not root readily if set at once, but if tied in bunches and buried upside down in the earth during the winter and set in the rows in proper position in spring they will root readily. We will not attempt to explain why this is so, for we do not know, but we do know the fact. In making cuttings for setting in the open ground our practice is to make them of the mature young wood of the past season's growth. We use three eyes or buds and cut off immediately below the lower bud and about half an inch above the top one. Where the wood is very short jointed it may be necessary to use more buds for we want the cuttings about ten inches long. The cuttings are set so that the top bud is just about the surface of the ground. If the soil where the cuttings are set is hard clay it will help the rooting if the trench is filled half full of sand in which to insert the base of the cuttings.

Propagation from single eyes is made only under glass in greenhouses where there can be had bottom heat in the bed from hot water pipes below. The cuttings are made in the fall and buried in sand till February in order to get calloused. They are then set horizontally an inch beneath the surface of the sand in the propagating bench, and when well rooted are potted into small pots, from which they are turned out later into the open ground. These make the very finest of plants, but can not be produced as cheaply as those rooted in the open ground.

Having strong growing vines of inferior grapes they can be easily grafted with better sorts. The vine to be grafted on must be cut down to about the crown of the root. A cion is used with three eyes, one being near the base. The stock is split straight across, and the short part of the cutting below the last bud is cut wedge shape and inserted as in the ordinary method of cleft grafting, care being taken as usual to have the young growing tissues between the bark and

wood cion and stock in close contact. If the stock is very large leave a small wooden wedge in the split to prevent the pressure crushing the graft. No wax is needed, but the soil must be heaped back over the graft. The advantage in this is that the root being strong and well established a bearing cane can be produced the first season.

Strong plants can be produced from old-established vines by layering. Take a young mature cane of the last season's growth near the ground. About two feet from the end cut a sloping incision half way through the cane. Bend the cane into the soil at the cut and pin it fast, and then turn the end up in an upright position and tie to a stake. By fall the layer will be well rooted and can be separated from the parent vine. The Scuppernong will root in this way without even making the incision, but it is better to make the cut as roots emerge more readily from the cut surface. Another method of increasing the Scuppernong and other of the Vulpina class of grapes is to make cuttings of the one-year wood about a foot long. Cut the lower end wedge shape and then take a piece of root of the same class of grape, the wild Bullace is as good as any, about three or four inches long. Split it in the middle and through this split insert the wedge-shaped end of the cutting, and then set it as an ordinary cutting. This will produce a much stronger vine in one year than a cutting without the piece of root, since new rootlets will be produced from the piece of root and the cutting too and both will unite permanently.

Planting the Grape Vine.

Grape vines grown from long cuttings will usually make two tiers of roots, and it is important in the South that both should be planted deep enough to grow. Some growers of experience prefer the long cutting plants, believing that the roots should be deep in the ground. In my own experience I have been led to prefer the plants grown from single eyes with long spreading surface roots. These are certainly best for a heavy soil, while the long cuttings may be better in gravelly or deep sandy soils where grapes are commonly grown in the South. Either can be made a perfect success by proper planting and culture. In setting the long cuttings we trim off the top tier of roots closely and shorten the lower ones to about six inches long. The end fibres will in any event be largely dried, and the new rootlets will put out more freely from the pruned roots. In fact we have come to the conclusion that pruning the roots of any tree at transplanting is as important as the pruning of the top. We are not ready yet to adopt entirely what is called the Stringfellow mode of trimming the roots to a mere stump, but we do know that finer trees and vines are made by fairly close pruning of the roots. Of the Stringfellow method we will have more to say further on. Thorough preparation

of the soil is as important in planting a vineyard as in planting an orchard of trees. Never plant on a heavy undrained clay soil if it can be avoided. A rocky hillside sloping to the east with a gravelly soil is an ideal place for the grape, and fine crops have been grown on deep sandy soils by proper fertilization. In fact no better grapes are grown than those produced on the pine barrens of North Carolina near Southern Pines. We grew there Niagara grapes with bunches of such size that they had to be packed in peach baskets, and the Delawares grown there are models of beauty. Good drainage and a warm soil and exposure are essential to success in vineyard culture. The distances for planting and the modes of training are innumerable. Where the old-fashioned training to stakes and spur pruning is practiced the vines can be set six feet apart each way. But this method is rapidly becoming obsolete in this country. In Europe and to some extent in California the vines are grown without support and are pruned back to mere stumps annually. But in the eastern section of the country some form of trellis training is essential. We do not propose in this bulletin to confuse the reader with a discussion of the innumerable methods of pruning and training, but simply to give the methods that have been found best in this State, and refer those who wish to study various methods to the numerous books on the subject.

Pruning and Training the Grape.

We have tested many methods of pruning and training and have finally settled upon what is known as a modification of the Munson trellis or what is now called the "Shelter trellis," as the best for our climate for the varieties of the bunch grapes. For the Scuppernong and other varieties of the Vulpina class there is nothing better than an overhead arbor made with good stout posts with wires stretched overhead high enough to work teams under.

Hence we will not attempt in this bulletin to discuss all the various methods of pruning and training, but simply to give what we have found best for the climate of North Carolina. The first season after planting after cutting back the vines to about three eyes from the ground at planting, we select the strongest shoot and then encourage the growth of this in every way possible, the object being to get a single strong cane. Side shoots will appear along this cane, and these we allow to make a single leaf and then pinch the growing point, keeping up this practice through the season, simply letting one new leaf form on the side shoot before pinching. We do this rather than pinch off entirely, to prevent the bud forming at the base of the shoot from starting for we want all these buds in perfect condition at the next pruning. During this first season a simple stake is all that is needed to tie the cane to. The following spring the trellis

should be built. I should have said that for the mode of pruning advised we plant the vines in rows ten feet apart and eight feet apart in the row. The trellises will then be ten feet apart, giving room to haul between each row. To construct the trellis we set stout posts of lasting material half way between each alternate vine or sixteen feet apart. These posts should stand six feet above ground. On top the posts pieces of 2 by 4 scantling two and a half feet long are firmly spiked to the posts by their middles. Galvanized wires are then stretched, one line along the line of the posts and two lines horizontal with the middle one along the ends of the cross pieces. The end posts must of course be well braced so that the wires can be stretched tight. If the canes have made the proper growth during the previous season they can now be cut at the height of the middle wire and tied to it. Any which are not yet strong enough for this must be shortened back to encourage a stronger growth, and trained up to the wire by stakes. Two canes are allowed to grow this season from the upper end of the cane and those below rubbed off. The growth of these canes is promoted by the same method of pinching during the summer as was practiced the first season. At the pruning for the third season these canes are shortened to four feet each and no summer pinching is practiced, except one pinching of the fruit shoots six or more eyes beyond the last bunch of fruit. The canes or arms are trained along the central wire and the fruiting branches hang over the side wires. The mass of foliage now completely protects the fruit beneath from the dashing summer rains, and it will be found that on a trellis of this sort the fruit will be almost as exempt from the rot without spraying as it will on a vertical trellis with abundant spraying. But this does not mean that the shelter trellis will do away with spraying entirely, but it makes the spraying more effective. In the subsequent pruning strong canes that grow near the centre of the vine are trained out as arms and the old ones are cut away. The vines are thus continually renewed and kept in the same shape as formed at first, and far better fruit is grown on these long canes than on the short spurs of the old spur system of pruning.

Of course the fertility of the soil must be maintained. If stable manure is available it may be used if reinforced with a due proportion of acid phosphate and muriate of potash, but we prefer in the vineyard to use a complete fertilizer of chemicals, since the excessive use of stable manure makes too rank growth and inferior fruiting. Since grape roots ramble long distances in search of food (I have traced the roots of old vines over 50 feet) the application should be to the whole surface after the first season, and a mixture containing about 3 per cent of nitrogen, 8 per cent of phosphoric acid and 4 per cent of potash will in most soils be a suitable one to use at the

rate of 500 pounds per acre annually. This is for such soils as are most favorable to the grape and which are generally deficient in potash. On red clay upland soil a smaller percentage of potash will be needed.

In the training of Scuppernongs and their allies the James and other black grapes of the Vulpina class we have said that the old southern method of horizontal arbors is the best. But the old notion that these vines do not need pruning is an error. They repay proper pruning as well as any, and if left unpruned they soon become a mass of tangled wood that makes the gathering of the crop difficult. The pruning will consist mainly of taking out the old and stunted canes and training out in good shape the strong and vigorous ones. No close pruning, as with the Labrusca or bunch grapes, can be practiced, for these rampant vines need plenty of room and wood for their best results. In planting Scuppernongs for vineyard they should be set about 40 feet apart each way if in strong land. For a year or more they can be trained to stakes till high enough to build the arbor. The old method is to make the arbor of cypress posts and place rails across for the vines, but it is better and neater to put cypress rails along the tops of the posts and stretch wires the opposite way two feet apart. After the vines have grown to meet on the trellis they will need no further cultivation but will be benefitted by a good mulch of rotted leaves and mold from the woods, and a dressing of the fertilizer mixture heretofore advised.

The Scuppernong does not set its fruit freely from its own blossoms, and where there are no wild bullace grapes in the neighborhood of a barren or staminate character it is always better to plant a male or staminate vine near by the arbor so that the crop will be fuller. In most places here where the Scuppernong is grown there are generally plenty of barren or pollen bearing wild vines near by, and the naturally sterile character of the Scuppernong is not noticed. But if there is a barren vine on the same trellis or arbor the crop will be much heavier on the fruiting vines. There are some cross-bred varieties of the Scuppernong and bunch grape which are highly praised, and which we hope soon to test for the benefit of our growers.

Varieties.

The suggestion of varieties of any fruits can only be made as suggestions, for they vary in their adaptability to the various soils and climates in the State, and a variety that is popular and profitable in one section may fail entirely under different soil and climatic conditions. Hence we will endeavor to suggest those that have been more generally successful.

The so-called Bunch grapes, as they are called here to distinguish them from the Scuppernong class, are generally members of the La-

brusca and Aestivalis species, though of late years many fine varieties have been produced by Mr. Munson of Texas by crossing these with the Lincecumei species, native to Texas. Many, also, of the Labrusca varieties are really cross bred varieties of Labrusca and Vinifera, the European grape.

Concord—The most general favorite for family planting. Succeeds everywhere, and grows strongly. Very liable to the black rot, and like most grapes needs careful attention to spraying to prevent this.

Champion—About the earliest and poorest grape grown, worthless except as a stock for grafting weaker-growing varieties on. The Delaware does finely when grafted on the Champion root.

Columbian—This is a strong grower and makes probably the largest grapes of any. It ripens early and is showy, but is of poor quality.

Campbell's Early—One of the newer and more promising grapes. It is early and of fine quality, and is probably the best very early grape.

Eaton—A seedling from Concord, but larger and more showy, and promises to be one of the best.

Ives—This is an old variety chiefly planted for wine-making. It colors early but is really late in ripening. A strong grower and a prolific bearer, and is a good grape when well ripened, but it colors so early that it is often gathered unripe and hence has a bad reputation for quality.

Moore's Early—A very early grape of the Concord class. Not so large in cluster as Concord but of good quality and well suited to the South.

McPike—We have not fruited this grape but it is very highly spoken of in the west, and is said to be of great size and good quality and a strong grower. It is regarded as one of the most promising grapes. It is a seedling from the Worden.

Worden—A fine large grape, similar to Concord but larger and of better quality. A strong grower and prolific.

Agawan—Formerly known as Rogers No. 15. A red grape of fine size and good quality. It grows strongly and is rather early in ripening.

Brighton—An early and high quality grape, but very liable to rot and mildew and needs careful attention and high culture. One of the very best when well grown.

Delaware—Probably the very best of the red grapes, and one peculiarly suited to the soils and climate of the South. The bunches are small and so are the berries, but the quality makes up for these, and the vine is very prolific. It was over propagated when first

brought out, and hence grew weakly, but has now recovered and is a fairly strong grower.

Brilliant—One of Mr. Munson's seedlings. The berries are larger than Delaware and of the same color. Skin very thin and flesh of high quality. It is too tender in the berry for shipping, but is one of the best for home use. It is a strong and healthy grower and very prolific.

Salem—Another of the Rogers grapes and probably more grown than any of them. Berries large, red and of good quality. Vine a good grower.

Diamond—This is the leading early white grape. Ripens before Moore's Early. A very strong grower and good bearer, and the fruit is of fine quality.

Empire State—A very strong growing vine, bunches large and berries of good size, and of good quality. Drops too easily from the bunch to make a shipping grape.

Perkins—A light reddish grape that has proved very well adapted to the central part of this State. Its freedom from rot and its luxuriant growth and productiveness make it desirable though the fruit is only of fair quality.

Lutie—A fine large red grape, and the freest from rot and mildew of any grape we know. It has a strong foxy aroma which some do not like, but the berries are to our taste as good as Concord and earlier.

Green Mountain—This was also sent out under the name of Winchell. We have the two growing side by side and they are identical. It is a very early grape, of the so-called white class, of a golden color when ripe and of very good quality. Will not ship well but is fine for home use.

Niagara—Probably the most popular and generally grown of all the white grapes. It succeeds finely in the South and is one of the best shipping grapes, as it ripens with the Delaware. These two varieties are almost the only ones grown in North Carolina for shipment North. The vine is a strong grower, and the fruit of fairly good quality, or about equal to Concord.

Mr. Munson, of Denison, Texas, has produced a great number of seedling grapes that are specially adapted to Southern conditions, and all of which we hope to test. Some of them we will fruit shortly.

Scuppernong Class.

Scuppernong—This is the popular Southern grape for late use and wine-making. It is of a russet color with a very thick skin and sweet juice. A rampant grower and usually grown on horizontal arbors one vine covering a great area.

Thomas—A large, black grape of the scuppernong class, and one of the best for wine.

James—This is the largest of the class. Skin thinner than the Scuppernong and black in color. Keeps well after cutting.

Flowers—A black grape of medium size and probably the latest grape grown. Quality very good.

La Salle—This is one of Mr. Munson's hybrids. Berry large and black. Quality equal to Scuppernong or better. Ripens earlier than any of the class.

San Jacinto—Another Munson seedling. Said to make a much larger cluster than Scuppernong and of better quality. Ripens two or three weeks after the Scuppernong and is very prolific.

We take these two last descriptions from Mr. Munson's catalogue, and hope soon to fruit the vines.

Efforts are being made by the U. S. Department of Agriculture in this State to test the practicability of growing the Vinifera grapes, such as are now grown in California, by grafting them on our native roots that resist the phylloxera insect. It is hoped that these experiments will succeed.

The Culture of Small Fruits.

Strawberries.

The culture of the Strawberry has become the most important interest in some sections of the State. The climate and soils of the coastal plain suit this fruit admirably, and its cultivation has become very extensive and profitable. The shipper to the northern markets wants the best early and productive sort that will carry well. Hence for his purposes earliness, productiveness and firmness of fruit are the leading considerations. On the other hand, the grower for home use wants not only earliness, but quality and productiveness, and if he gets the quality it is immaterial to him whether the fruit would ship well or not. Then, too, he wants mid-season and late varieties to prolong the season. Therefore, in the consideration of varieties we will make the distinction between those best for home use and those for market.

Propagation.

The Strawberry naturally propagates itself by making runners which root along the rows. The best plants are always to be had from new plantations during their first summer and before they have become exhausted by fruiting. The transplanting can be done at any time when good, well rooted young plants are to be had. If plants are set in late summer and a good stand is had they will pro-

duce a fair crop of fruit the following spring, but the most certain time in the warmer sections of the State for setting the plants is in November and December. The summer heat and drought is then over and the soil is moist and the plants live easily.

Preparation and Planting.

There is no better preparation for a Strawberry plantation than the growing of a crop of cow peas on the land the previous season. Where the object is to get a field in the best condition for Strawberry planting, it is a good practice to plow under the whole growth of the peas deeply as soon as frost has killed them, if the planting is to be done in the spring, which is the best time for planting in the elevated western section of the State. But if the planting is to be done in the late fall, it will be hard to get the land in the proper order if the whole growth is turned under. Hence it will be better to mow the peas for hay in September and then plow and prepare the stubble only. The plowing and preparation of the land should be of the most thorough character. On the black sandy soils of the eastern part of the State, where the great Strawberry fields are located, we would only advise a good plowing, but on the red clay soils of the upland districts it will be a great advantage to follow in the furrow of the breaking plow with a subsoil plow and loosen the subsoil to a depth of at least fifteen inches. The plants will then fare much better in a drought than if the soil is shallowly plowed, for the Strawberry is a deep-rooting plant when it has the chance to run down, and it is very fond of moisture, always doing better on lands where the soil water is not far from the surface. Heavy manuring with commercial fertilizers is better for the Strawberry than the use of stable manure, which is apt to give trouble by bringing in weeds and grass and white clover. With proper moisture conditions in the soil the next most important thing is fertility. On old garden soils that have been enriched for generations there may be little need for heavy manuring, but on most of the lands devoted to commercial Strawberry growing the fertilization of the soil is the most important matter. The plants are gross feeders, and the difference between a heavy crop of fine fruit and a dead failure generally depends on the liberality with which the fertilizers are applied. In preparing to plant run furrows four feet apart, and in these scatter a liberal supply of a high-grade complete fertilizer. The following will be a good mixture for planting time: Acid phosphate, 900 pounds; cotton-seed meal, 900 pounds; muriate of potash, 200 pounds—to make a ton. Of this use 500 pounds in the furrows at planting time and 500 pounds more with the first working in the spring, applying it on all the space between the rows. After a crop of fruit has been taken off the soil should be thoroughly worked and another 500 pounds of the fertilizer worked in per acre.

We set the plants about fifteen inches apart in the four-foot rows and then train in the runners alongside the rows so that the next season there will be a thick matted row. Never keep a strawberry plantation longer than to make two crops. Plant a patch every fall or spring, according to location, and plow down the old plants after they have made the second season's crop. In this way you will always have one patch bearing its first fruit and one in full crop to be plowed down after the fruit is off and to be followed by a new planting that fall.

Care of the Plantation.

In all parts of the State east of the Blue Ridge there is no need for a mulch on the Strawberries as a winter protection, but in the colder region west of the mountains a light mulch of straw over the whole bed will be a protection of value. A light cultivation should be given the first thing in the spring as signs of growth begin, and at that time a mulch of pine straw should be placed between the rows for the double purpose of keeping the fruit clean and for pulling over the rows when frost threatens and the plants are in bloom. At this first working it will be a decided advantage to give the bed a dressing of nitrate of soda at rate of 100 pounds per acre, scattering it ahead of the cultivation and when the plants are dry. If applied when they are wet with dew or rain any that touches the leaves may scorch them. The great need of the Strawberry is water. Not water standing in the soil, of course, but a soil not too greatly elevated above the water table in the soil. Soil of moderate fertility, if of a moist character, will make more berries than rich soil in a more elevated and dry situation. A moist, dark sandy soil, such as is plentiful in the eastern part of the State, is an ideal soil for the Strawberry, and such a soil will stand heavier use of commercial fertilizers than a dryer soil, because the fertilizer will be better dissolved. We have seen very minute directions given in print in regard to the setting of Strawberry plants by spreading the roots out horizontally and placing the soil compactly over them. We prefer to set the plants with an ordinary garden trowel, opening up a hole, placing the roots in behind the trowel and then letting the earth fall back with the roots straight down. Care is needed not to plant too deep so that the crown bud will be covered and on the other hand not too shallow so as to leave the top of the roots exposed.

Growing Pot Plants.

Go through the patch when the first runners begin to make roots and take them when they have made little white roots about an inch long. Have ready some three-inch flower pots and pot the plants in these, using a rich and well-mixed compost of old rotted manure

and rotted sods that has been piled and turned for months till fine and mellow. Then place the plants close together in an ordinary cold frame on a bed of coal ashes to keep the worms out of the pots. Place over them a screen made of laths tacked an inch apart, and attend regularly to watering them. They will soon have the pots well filled with roots and can then be knocked out and planted at any time with perfect success and a full crop can be had from the plants the following season. Many books tell about growing potted Strawberry plants, and as a rule tell the inexperienced grower to fill the little pots with compost and bury them along the rows and place the runners on them to root. Any one who has ever tried this laborious plan will be apt to abandon it soon. It is a great deal easier and better to take the partly-rooted runners and pot them at a bench in the shade, where you can pot a thousand while you would be crawling over the patch to plant a hundred, and the plants all being put where they can be regularly watered, will grow much faster and better. The nurserymen, who grow potted plants by the thousands, would be very foolish to crawl over the ground to bury pots, and they could not possibly sell them at a reasonable price if they did this. They often try to make their customers think they do, but they don't.

Cold Frames.

These pot-grown plants are the only kind that should be used in planting frames for forwarding the fruit. They can be set in the frames about ten inches apart each way in September or October. The soil in the frames should be made as rich as for the growing of a crop of winter lettuce. Any runners that may show on the plants in the fall should be regularly nipped off, and all weeds kept down. The frames should be left fully exposed during the winter till about the first week in February, when the glass sashes should be put on. Careful attention should be given to airing the frames in sunny weather, and closing them up at night. When a warm rain comes strip the sashes down and let the bed have the water, and if the soil gets dry and no rain comes they should be well soaked with water. If the frames are carefully attended to the fruit should be ripe from two to three weeks ahead of that in the open ground, and when grown in quantity the artificial culture should be made a very profitable matter. The time is close at hand when our market growers will have to adopt some of the intensive methods used by the northern gardeners if they are to meet successfully the competition from Florida and the other States South of us. When one becomes skillful in the use of simple glass sashes he will soon be wanting to go into regular winter forcing with heated green-house. Our gardeners have hardly realized what profit there is in intensive

culture under glass. The northern gardeners have successfully met the southern competition by covering acres of land with heated green-houses and producing therein products of such great excellence as to command far better prices than the southern products without such aid. One grower near Boston has found that it there even pays him to use arc electric lights over his green-houses in the production of lettuce. Here, our abounding sunshine, even in the coldest weather, gives us a great advantage over the northern growers, and we have no need for such expensive lighting as they find needed in their dark and cloudy winter, where, as one gardener recently told me, he has seen six weeks pass without one whole sunny day. Some day our growers will realize the immense advantage their sunny climate gives them for the use of glass and they will then wonder why they so long used the makeshift of cloth on their frames.

Forcing in Winter.

As some of our readers who have green-houses may wish to experiment with Winter Strawberries, I will briefly detail the method to be used. Some imagine that they can take up plants from the garden and put them in pots and force them at once. But this can not be done. It takes careful preparation to get plants in shape for forcing. The plants are started just as we have described, in three-inch pots. As soon as these pots are filled with roots they are repotted into four-inch pots and when these are filled with roots into six-inch pots, in which they are to be forced. The pots are placed handy to water, on a bed of coal ashes to keep the worms out of them, and they are encouraged to grow and make strong crowns, which are essential to fruiting well. All runners must be rigorously kept off, and the pots kept clean of weeds. As the weather grows cold the pots are plunged to the rim in coal ashes and left exposed to the weather and allowed to get a little dryer, but not too dry. They must be allowed to go to rest, for they can not be well forced till they have had some winter rest. About first of January they can be taken into the house and the old leaves cleaned off, and the surface of the soil in the pots carefully stirred. For a while the temperature of the house should not exceed 45 degrees at night. As new growth starts the temperature should be gradually raised till finally they are in a night temperature of 60 degrees. Careful attention must be given to airing the house in day time to prevent too high a heat. Watering must be regular, and once a week they should have a dose of liquid manure made by dissolving cow manure in water to the color of tea. The first essential in forcing is to have the pots well matted with roots, for if you apply liquid manure to plants that have not gotten full possession of the soil you will sour

the soil and ruin the plants. Never water till there is need for it and then soak all through, an always apply the liquid manure after a good watering and not when the plants are dry. The pots must be set far enough apart to allow the fruit to hang clear of other pots. A variety with perfect flowers should be used for forcing, and it is of advantage to go over the plants every day at noon and apply the pollen to the pistils of the flowers with a camel-hair brush. The novice will usually make at least a partial failure in forcing till he gains experience in handling plants under glass, but when well done the forcing of Strawberries can be made profitable. They are marketed in small fancy paper boxes and bring, of course, many times the price of the outdoor crop, for when well grown by a skilled hand the fruit is of remarkable size and beauty. When our gardeners acquire skill in the use of green-houses there are many things besides Strawberries that can be forced and at a great profit, too.

Varieties.

These are now so numerous, and new ones are coming out annually with great claims for excellence from their growers. The southern grower is mainly concerned in getting the earliest and most productive berry of good size that will ship well. These qualities are hard to combine, and the catalogues will give the planter little help, for every variety listed is commonly praised all that the grower can, and the inexperienced buyer is often puzzled to know which are really the best, when all are claimed to be best.

Lady Thompson.—This has long been the leading variety shipped from Eastern North Carolina. It seems to be particularly suited to our conditions, but is not popular in the North. It is quite an early variety and a vigorous and healthy plant, and it holds its popularity with the growers better than almost any other sort.

Clyde.—This has been highly praised and is a productive variety of very moderate quality. It colors poorly, in our experience, and is not so early as the Lady Thompson. It is firm and ships well.

Brandywine.—A wonderfully vigorous grower and a fairly good bearer of large and fine quality berries of fine color and firm. It has perfect flowers and is a good pollenizer for the pistillate ones. It is a mid-season and late berry.

Hoffman.—One of the prettiest, firmest and best of the very early ones, which has been largely discarded for varieties of less value. We know of no very early berry yet brought out that is better than the Hoffman.

Excelsior.—This is a very early and prolific variety, but in our trials is always small, too small to make a profitable shipper. It may do better in the moist soils of the eastern part of the State, but here it is of little value.

Gandy.—This is the best very late berry—of good size and firmness and good quality, though rather rough in appearance.

Michel.—Another very early berry, which is good to illustrate how worthless a Strawberry can be. Earliness is the only good quality we ever observed in this variety, as it has been with us small and very unproductive.

Seaford.—A very large and productive mid-season berry. Its immense calyx makes it look rather rough in the boxes, but it is a fine berry and a good shipper.

Howell.—Very large and a good cropper. Colors well but is rather soft.

Nick Ohmer.—A strong plant and a fair producer of immense berries; rather late.

Sharpless.—An old rather early and mid-season variety that holds its own as well as any. It does not do well on our dry soil but is fine on low lands.

Barton.—A very handsome and productive berry. Colors beautifully, but seems too soft for shipment.

Parker Earle.—Of no value whatever here. It sets an immense crop of fruit, but brings little to perfection. We have discarded it as worthless.

Jessie.—The Jessie, as we had it ten years ago, was a very large light-colored berry of fine quality, round in shape and productive, but too soft for market. Jessie, as we have now gotten it, is a different berry and worthless for any purpose.

Pride of Carolina and *Patrick* go out along with Parker Earle as not worth the space they occupy.

McKinley.—One of the earliest berries and of fairly good quality and size at first, but soon runs down small. Very productive, and on more moist soil may be valuable.

Cumberland Triumph.—One of the oldest varieties, but yet hard to beat. A strong grower and very productive of berries of a large size and showy appearance.

Johnson's Early.—Did not prove early here, and was a very poor bearer of small fruits.

Mexican.—Of no value at all, so far as we can judge from two seasons' trial.

Ridgeway.—This is one of the very best mid-season berries—showy and very productive. We would plant this largely.

Sample.—A showy and high-colored berry, but like Barton, to soft to ship well.

The list might be extended further, but these include not only the best, but the most worthless. We have said just what we think about each from our own tests.

RASPBERRIES.

In the language of the nursery, there are but two classes of Raspberries—the Red Raspberry and the Black Cap. But the term Red Raspberry includes varieties belonging to different botanical species, possessing different characteristics as to hardiness and quality, as well as color, for there are some of this class of a yellow color, as there is also in the Black Cap class. There are also some varieties which, while not truly red, are reddish purple and are, therefore, by nurserymen classed as red. The main distinction between the two nursery classes is in the way they are propagated, for while almost any Raspberry may be grown from root cuttings with bottom heat under glass, the Black Cap class make few suckers from the roots and propagate slowly in this way, and are commonly grown by rooting the tips of the mature canes of the same season's growth. These are by far the best plants to be had of the Black Cap class. The Red Raspberries, whether belonging to the European or American, species are all easily increased by root cuttings planted in the open ground in the spring, or from suckers from the old stools. These last, however, should never be used if plants grown from root cuttings are to be had. The highest flavored of the Red Raspberry class are those derived from the European Rubus Idæus. But these are tender in the North in winter and easily injured by the sun in summer in the South. In fact, in all the warmer sections of this State the Red Raspberries are not so productive as they are in the Middle States, though they are still worth growing for the home use and the local markets. The Black Cap class are far more productive here. In our western mountain country all varieties of the Raspberry reach their highest perfection, and even where the fruit can not be marketed fresh they may be made profitable by evaporating. In fact, the modern fruit evaporators offer a great opportunity for profit to those in the western section remote from railroad facilities. The chief trouble in the warmer parts of the State with the Red Raspberries is their liability to have their canes killed in summer. Hence we should select for these the coolest soil at hand. Even in the shade of orchard trees they will bear well, and in the home garden the best place for the Raspberry bed is along the north side of a board fence where they will be sheltered from the heat of the sun. With the Black Caps we have found it an advantage to pinch the young canes during the summer to cause them to branch and take on a more bushy habit. The plants should be set in rows six feet apart and the plants three feet in the row. The best method we have tried for training is to set stout posts at intervals along the rows and stretch a single wire from post to post about four feet from the ground. The fruiting canes are then tied out fan shaped

to this wire. The cultivation should be of the cleanest, but shallow, so as to avoid the cutting of the roots and the increase of suckers as much as possible. For a fertilizer for the Raspberry there is nothing better than a compost of stable manure and woods earth piled up in the spring and turned frequently during the summer to be applied liberally during the following winter. When the land is kept fertile by this means a plantation of raspberries will last in productiveness for many years.

Propagation.

For the increase of the Red Raspberry class take up some old stools and cut the long roots into pieces about three inches long. Do this in the fall after the leaves have fallen. Mix the cuttings with sand in a box and bury it in the earth for the winter. In early spring prepare a nursery bed thoroughly and mark out shallow furrows in which the cuttings are dropped closely and then covered. As they shoot above ground the cultivation must begin and be kept up clean during the summer. In the fall the plants will be ready to transplant to their permanent quarters. In the case of new and scarce varieties the propagation can be done more rapidly under glass in a heated green-house. Many years ago, when the Herstine Raspberry was first brought out, a friend bought two large plants for which he paid $2.50 each. This was about the first of January. Seeing that the plants had an abundance of long roots I told him that if he would let me have them I would propagate them during the winter and give him one half in the spring. He agreed to this and gave me the plants. I cut the roots into one-inch pieces and placed them in the sand of the cutting bed in the green-house where they had a strong bottom heat. As fast as they showed any growth they were lifted from the sand and potted into three-inch pots and placed in a cool green-house. When the roots of the old plants were trimmed I potted the stumps and placed them, too, in the green-house. When my friend came in the spring I gave him 129 plants for his share, greatly to his surprise, and each one of the potted plants made as good a plant the following summer as either of the old plants would have made. At the same time I took him into the green-house and showed him the ripe fruit on the old canes. This rapid propagation pays well when the plants are selling at fancy prices, but will not pay when they have come down to the normal price of root cuttings. But it shows what can be done by skillful propagation. When the Philadelphia Raspberry was new and high priced a grower in New Jersey thought to get ahead of the market and built a long green-house for propagating them. He filled this house with cuttings of the ripe canes and failed to grow a plant. Had he known the nature of the plant he was working with and had

filled the house with root cuttings he would have had a great success instead of failure.

The propagation of the Black Cap varieties is done in a different manner. They are difficult to grow from root cuttings, and the common method is to layer the tips of the long canes in the soil along the rows about midsummer. Each tip is pegged fast and covered with soil and they root with great ease and make plants with a great mass of roots ready for the planting in fall or spring. The Dewberry can be increased in the same way. Some Raspberries have a habit of making fruit in the fall on the young growth of the same season. Most of these belong to the European strain, but some American varieties have the same habit. These fall-bearing Raspberries are seldom very productive in the ordinary season, and if a full crop is desired in the fall the canes should all be cut to the ground in the spring, and only the fall crop looked for. Where, for any reason, it is not desirable to train to horizontal wire a good plan for training the plants is to set a stake on each side of the hill and tie part of the canes to one stake and part to the other. Where the growth has been strong the canes should be slightly shortened back in tying them up in spring.

Winter Protection.

In the warmer part of the State east of the mountains all Raspberries are hardy in winter, but are all the better if laid flat on the ground during the cold weather. In the mountain country all the Red Raspberry class will be safer with an efficient winter protection. The best way to accomplish this is to gather the canes in a bunch, bend them to the ground as flat as possible and cover with earth. The native Blacks Caps will not be hurt by full exposure. In all parts of the State the Trailing Blackberry or Dewberry is safer lying flat on the ground in winter or covered where winters are very cold.

Varieties.

Cuthbert.—This is about the only Red Raspberry which we have tested that has been found to succeed well in our climate. It needs rich and moist soil of rather a heavier character than that for the Strawberry, and the canes should be kept pinched to induce a bushy growth and to enable the plant to resist the summer heat.

Gregg.—This is about the best of the Black Cap Raspberries that we have tried.

Shaffer.—This belongs to a different class from either of the above. It seems peculiarly suited to southern conditions, and while not remarkably prolific its fruit is of the largest size and a pleasant

acid flavor. If cut to the ground in the spring the young canes will make a fine crop in the fall. It is well worth growing in the home garden. In fact, except for a local market the Raspberry is hardly worth growing in the South, except for home use. This means for the warmer part of the State. In the mountain country west of the Blue Ridge any of the varieties of Raspberries grown in the North will do well.

BLACKBERRIES AND DEWBERRIES.

The Blackberry, both of the high bush sorts and the Trailing Blackberry, or Dewberry, as it is called, are becoming one of the most profitable small fruits for market in this State after the Strawberry. Following the Strawberry crop closely, the Dewberry and the earlier varieties of the Blackberry come in very well with the grower of small fruits to keep up the shipment later in the season.

Propagation.

What has been said in regard to the propagation of the Raspberry is equally applicable to the Blackberry. The plants of the bush sorts grown from root cuttings are always more desirable than the suckers from the old stools, as they are far better supplied with roots. The sucker remaining attached to the old plant and supported largely by it, does not develop the mass of roots the plant grown from a separated roots cutting does, and the root cutting plant will always make a finer growth of canes the first season. The Dewberry, as we have intimated, can be propagated in the same way the Black Cap Raspberries are, by rooting the tips of the canes. Very few of the Blackberries in cultivation have resulted from nursery-grown seedlings, nearly all of them having come from chance plants found growing wild. There is great room for more intelligent culture and the growing of seedlings from selected varieties, as is done with other fruits.

Recently there has been sent out a plant under the name of Loganberry, which is claimed to have been the result of a cross between the Blackberry and the Raspberry. The fruit is reddish in color and the size of a large Blackberry. It has decidedly a Raspberry flavor, and it opens up a possibility in the crossing of these fruits that may lead to good results. The Loganberry, in my experience, has been very unproductive, though the fruit is good. It is very slow of increase, as it will not grow from root cuttings. The only way so far in which I have succeeded in propagating it is to pot some old plants in the fall and keep them in a cool house till mid-

winter and then bring them into a growing temperature and as the side shoots grow take them off when inch or two long and root them in the propagating bed with a strong bottom heat. This is too slow for commercial purposes, and the plant will be scarce for some time. But in its present shape it is not of any value for market purposes on account of its unproductiveness. It may become the parent of better kinds in the hands of diligent improvers.

Planting and Culture.

The same directions given for the planting and training of the Raspberry will apply equally to the Blackberry, at least to the bush varieties. We plant them in rows six feet apart and three feet between the plants in the rows, and tie the canes to a wire in the same way as Raspberries. An exception to this should be made with the Dewberry. Some have practiced the training of the long canes to a wire stretched about two feet from the ground, and some have substituted a hoop pole for the wire, as the canes are apt to chafe in the wind against the wire and get injured. We prefer to tie the canes to tall stakes similar to the poles used for Lima beans in the garden. Trained in this way the plants can be set five feet apart each way. After the fruiting is over the young canes should be trained in along the rows to be out of the way in cultivation, but they should not be tied up to the stakes till the following spring, since they are safer during the winter on the ground, which is their natural place, and if tied up in the fall they may be seriously injured during the winter.

The long canes of the Dewberry should be shortened very little, but the weak surplus canes should be cut out entirely. The canes of the bush sorts in a fertile soil will need considerable cutting back in spring, and during the growing season all suckers that are not needed to reproduce the hill should be kept chopped out at the surface of the ground, as deep digging will only tend to multiply them.

Varieties of Blackberries.

Lucretia.—This is about the only one of the Trailing Blackberries, known as Dewberries, which has been grown to any extent in the South, and so far it is about the only one worth growing. It is early, large and productive, though it seems to be more subject to the disease Anthracnose than most other Blackberries.

Wilson's Early.—This has been for many years the standard early Blackberry. It is claimed to be a cross between the Dewberry and the High Bush Blackberry, and its habit of growth would seem to confirm this. It is an early and very large berry, and always brings the top of the market. The chief difficulty with it is its ten-

dency to run into double flowers, thus making very pretty white roses but no berries. Owing to this habit is has become risky to plant.

Wilson Junior.—Is claimed to be a seedling of the above, and better. We never have found that it is in any way superior to the old Wilson.

Early Harvest—A very early berry, coming right along after the Lucretia Dewberry. It is smaller in size than Wilson and generally sells for less per basket, but its immense productiveness more than atones for this, and its firmeness for shipping is also in its favor. We regard it as about the most profitable Blackberry for the South.

Kittatiny.—This is, in our opinion, the finest Blackberry grown. The canes are stout and vigorous and the fruit very large and fine. It is not very early, however, and will be bettter here for the home garden than for market. Its main fault is it liability to the red rust fungus.

Iceberg.—This is the best White Blackberry yet introduced. It is valuable as a curiosity and for the home garden, but has no market value and is very late.

There are some newer varieties offered with great claims, and we hope to test some of them, but here give only such as we know from experience.

GOOSEBERRIES AND CURRANTS.

The Gooseberry is only adapted to culture in the cool valleys of the mountain country. There it may be useful for the home garden. In the warmer parts of the State it is uniformly a failure, and in no section is it of value as a market fruit. The fruit is usually sold green and the supply for the northern markets comes from nearby plantations, where the Gooseberry is seldom considered very profitable. Currants, too, are better adapted to the western and cooler parts of the State, though in cool, moist soils they will produce fair crops in other sections, but not to the extent to make them of value as a market fruit. The finer varieties of the Red Currant might be made profitable in the elevated western part of the State. Gooseberries and Currants are both almost unknown in the warmer parts of the State even in old gardens.

They are both easily propagated by cuttings of the one-year wood made about ten inches long and set in the open ground in the fall in nursery rows, and transplanted to their permanent location in the following fall. It is useless to attempt the cultivation of Gooseberries and Currants except in the more elevated and cooler sections of the State.

Gooseberries.

It is useless to plant Gooseberries anywhere in the State except in the elevated valleys of the western mountain country. In the warmer part of the State they are utterly worthless and will not make fruit.

Downing.—This is an American variety, and about as good as any, as none of the large English sorts are of value in this country.

Currants.

While not so absolutely certain to fail as the Gooseberry in the warmer parts of the State, the Currant is, nevertheless, far less productive here than in the North. In the mountain country in moist bottom land they will do finely. Here they need a moist and fertile soil and a half shaded place.

Red Dutch.—This is the oldest variety and about the heaviest bearer. The White is similar, except in color.

Cherry.—This is a far larger currant than the Dutch, but less productive and smaller in cluster.

Fay.—This seems to combine the good qualities of the above. Larger in bunch than Cherry, as large in berry and as prolific as the Dutch. It is about the best red currant.

Bulletin No. 188 **September, 1903**

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

FIG. 1—A Wilting Plant.

The Granville Tobacco Wilt; a Preliminary Bulletin.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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The Director's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C

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THE GRANVILLE TOBACCO WILT;* A PRELIMINARY BULLETIN.

By F. L. STEVENS and W. G. SACKETT.

INTRODUCTION.

A disease of tobacco so destructive that its spread throughout the country would imply annihilation of the industry of tobacco growing has made its appearance in Granville County, North Carolina. Since the chief symptom of the disease is a wilting of the leaves it is appropriate to know the disease as a wilt. Inasmuch as other wilts may have been or may later be found to affect tobacco plants, this wilt may further be distinguished as the Granville wilt, naming it after the county in North Carolina whence it was first accurately described.

The disease is spreading and the object of the present bulletin is to call attention to its nature, and to indicate such measures of prevention as may check or stop its spread into regions at present unaffected.

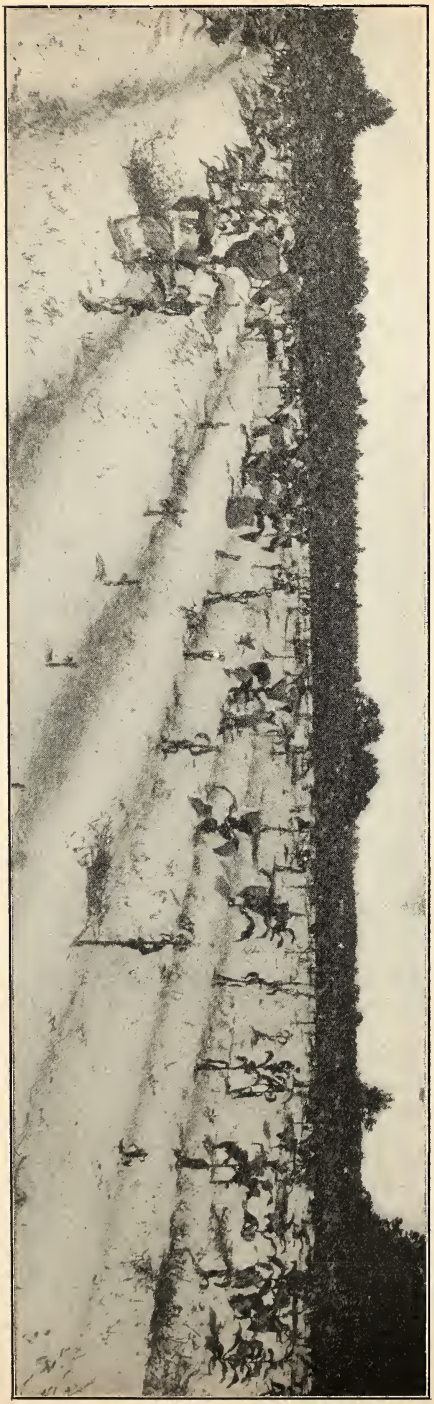
Description.

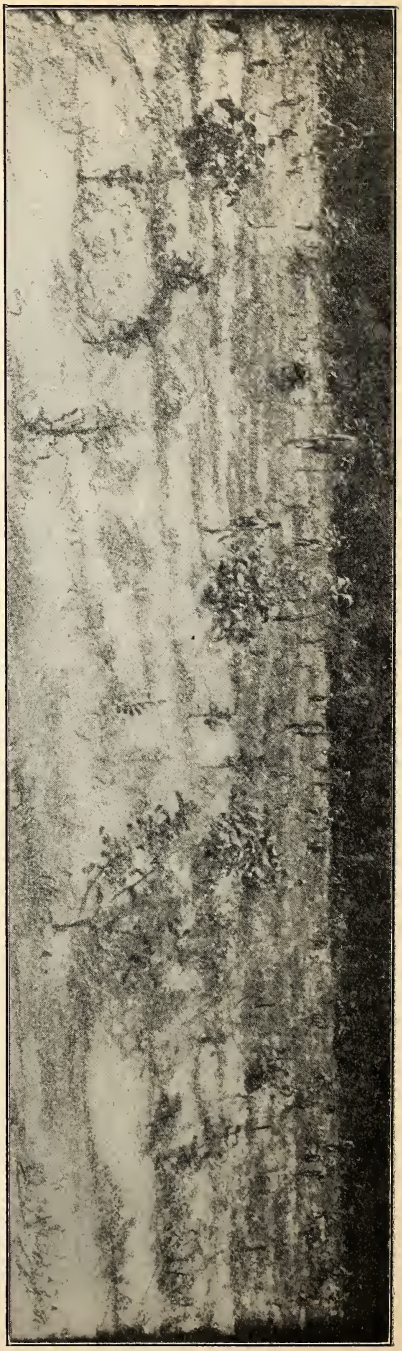
The Wilting.—The first indication of the disease is given through the leaves which droop, becoming soft and flabby as though suffering from want of water. This symptom is not accompanied by any change in color; the leaves remaining green for some time after the wilt appears. As a rule the lower leaves droop first, the wilting gradually proceeding from the ground upward. A typical case is shown on the front page of this bulletin. Frequently the leaves on one side of the plant, as is shown by one of the plants in fig. 5, succumb earlier than those on the other side. Some growers believe that one side of the plant may occasionally survive to maturity, though the other side be wilted, but that is not usual. Frequently even a single leaf will show one-sided infection.

The wilted leaves soon die, dry up and eventually the whole stalk dies. It then remains standing with its dead leaves still hanging as in fig. 8. It is thus not to be confounded with temporary wilting due to lack of moisture, excessive heat, etc.

The Stem.—At the stage of earliest wilting a section across the stem shows a yellowish discoloration of the woody portion. In more advanced stages, or in sections taken lower on the stem, the wood is

* This disease has been known to the Station for two or more years. The number of queries concerning it and its evident seriousness leads to special investigation of it at this time. A press bulletin has already been issued by this Station (August 22) under the caption "A Dangerous Tobacco Disease."





FIGS. 2 and 3—Two badly wilted fields near Creedmore, N. C.

found either on its inner or outer parts to be penetrated longitudinally by black streaks, varying in size from that of a cambric needle to that of a knitting needle. These streaks are so abundant in stages immediately preceding death that the whole or nearly all of the wood seems to be so affected. Frequently similar streaks penetrate the pith, though this is only in the most extreme cases. The black streaks in the wood are usually more abundant adjacent to the cambium than to the pith, and simply removing the bark from near the base of sick plants, discloses them in abundance. The blackening often progresses from the wood outward through the bark, producing shrunken, blackened patches on the surface of the stem.

In more advanced stages when all the leaves are wilting the wood and bark at the base of the plant are blackened nearly throughout and the pith has decayed leaving the stem hollow or filled with a soft, rotten residue. The bark near the level of the ground turns black, and becomes dry and hard. The pith and wood in the upper portions of the plant usually dry up before decay overtakes them resulting in the collapse of the upper portions of the plant in irregular longitudinal folds in parts where the woody layer is too soft to maintain the shape of the plant when the support of the distended pith is withdrawn.* If a badly diseased plant be cut off near the ground, a dirty yellowish exudate issues from the cut wood, accumulating in a layer one or two millimetres thick. This exudate is slightly viscous, hanging together in strands two to four millimetres long when picked with a knife point.

The Root.—The root seems to be the seat of the original infection, and any plant in a stage of disease advanced enough to show symptoms in its foliage will be found to possess roots already in an advanced stage of decay. In early stages one root or more may be diseased (fig. 10); in later stages all succumb (fig. 11); in the more advanced stages of disease in any root the bark is black, soft and dry, a spongy mass of fibre left by the decay of the more watery parts. In the worst cases even this spongy covering may drop off leaving the wood of the root bare and dry. Usually, however, the bark remains as a spongy layer, surrounded by a dry papery jacket more or less cracked transversely, the remains of the epidermis. The decay is characteristically a dry one, although if the soil be wet with rain the decayed residue may become slimy, wet, and mushy.

The wood of the root undergoes changes similar to those of the stem. In the root as in the stem the disease manifests itself earlier in the wood than in the bark, appearing first as longitudinal streaks of black, in that portion of the woody cylinder lying close to the bark. The disease is most conspicuous in the largest roots, but the

*The stem consists of three portions: the innermost portion is the pith; surrounding this is a hard layer of wood, and the outermost layer is the bark. The wood and the bark are separated by a very thin juicy layer known as the *cambium*.

FIG. 4—Portion of a wilted field showing all stages of the disease.

FIG. 5—Dead plants replaced by cow peas. Plant on left shows wilt on half of one leaf.

FIG. 6—Two plants wilted, others healthy.

FIG. 7—In middle stage of wilt.

FIG. 8—In last stage of wilt.

smallest fibres, upon close examination, are seen to be similarly affected. In cases where the woody cylinder is blackened before the adjacent bark shows injury the smaller feeding roots, which pass from the diseased wood through the still healthy bark die. They are infected by or they infect the wood of the central cylinder.

When all the roots of a plant are diseased death is naturally more rapid than when a few only are affected, and in such cases the progress of the decay of the stem is cut off by the death of the plant. Thus in the plants most badly diseased the disease does not reach so high as in plants less affected. The wood midway up or near the top of such plants shows no blackening, barely a slight yellowish tinge is evident.

Spread of the Disease Through the Plant.

If one root only be primarily infected the blackening of the woody parts progresses to that side of the stem nearest the affected root, spreading much more rapidly longitudinally than transversely. Thus it happens that frequently a blackened streak may be traced from a single diseased root for a considerable distance through the length of the plant; sometimes even to a leaf, or to one side of a leaf. In such cases the side of the leaf bearing the affected woody strand is the first to wilt, and conversely if a section be made through the stem of a leaf, one side of which is wilted, it will be found that the corresponding woody strands of the stem are blackened.

It seems that the infection is first in the root, and that the spread in the plant is principally longitudinal, although a lateral spreading leads eventually to the involution of the whole plant.

How the Disease Differs from "Sore Shin."

Several diseases are classed by tobacco growers under the general names of "sore shin," "sore leg," etc. The Granville wilt may readily be distinguished from these by the diseased roots and the black streaks in the wood. In "sore shin," too, the plant usually topples over, while in the Granville wilt the stem remains erect.

Facts Known Concerning the Spread of the Disease.

Corroborative evidence from tobacco growers seems to establish definitely that this disease increases in violence upon a given field year by year after the first infection. In the first year of its occurrence in a field, a few plants only may be affected. The next year that tobacco follows on this field larger regions are affected. A third year without protracted rest from tobacco growing would probably in every case bring on conditions as deplorable as those shown in figs. 2 and 3, a common sight near Creedmore.

FIG. 9—Root in center healthy, others in various stages of disease.

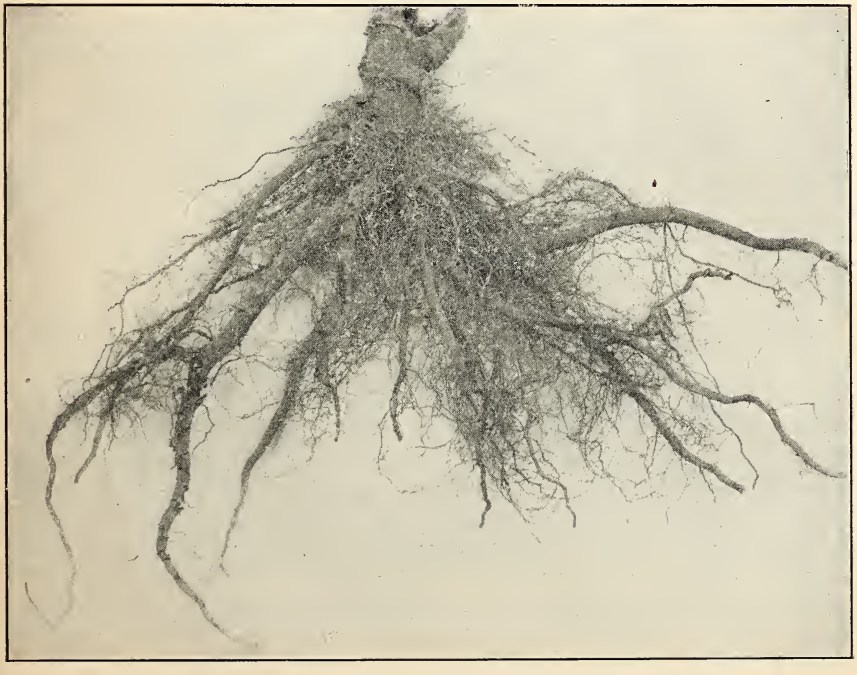


FIG. 10—Root to left badly diseased; from plant similar to the wilting one shown in Fig. 5.

It is further noticed that soil once seriously affected may recover to some extent and regain its ability to raise healthy tobacco if crops other than tobacco be raised and no tobacco be put upon the ground.

When an affected field lies at a higher level than healthy soil, and in such position that flood-water may flow from the sick field to the healthy field, the healthy field will be thereby contaminated. There are numerous well marked instances to show that in such cases the affected region of the second field is primarily that part which received wash-water and soil from the higher lying affected field. So, too, in a field slightly affected the spread of the disease is with, not across, the row as though the contagion were carried back and forth in the operations and by the tools of tillage. An instance of this is presented in fig. 13, where the diseased spots tend to follow the row.

FIG. 11—Root from a plant like that shown in Fig. 8.

DAMAGE.

In regions where the chief money crop must be tobacco, where the soil is preeminently a tobacco soil, the damage wrought by this disease is very great. It does not take merely an occasional plant, but rather the majority of those in the field. The accompanying illustrations present to the eye a general appearance of some fields near Creedmore, while the map, fig. 13, may convey still more accurately an idea of its devastating effect. So great is the injury on those fields that it may be called practically complete destruction of the crop.

The disease resides in the soil. A field with only a few sick plants one season on the next planting will have many, and another planting in tobacco would mean that practically all of the plants must

succumb. The damage therefore is not measured merely by the loss of one crop. The greatest loss is the permanent injury to the soil, prohibiting further culture of tobacco unless some remedy be happily discovered.

History and Distribution.

This disease while apparently new to literature has been known by the farmers of Granville County for some years. There is some difficulty in securing reliable data concerning its first appearance on account of vagueness and inaccuracy of descriptions, and the confusion of the disease with other diseases. It seems quite certain however that at least as long ago as 1881 there was a serious outbreak of the wilt near Hester, and that in 1890 and '91 it was destructive near Bennehan, the regions between these points meantime becoming involved. More recently a field near Tar River has been badly stricken.

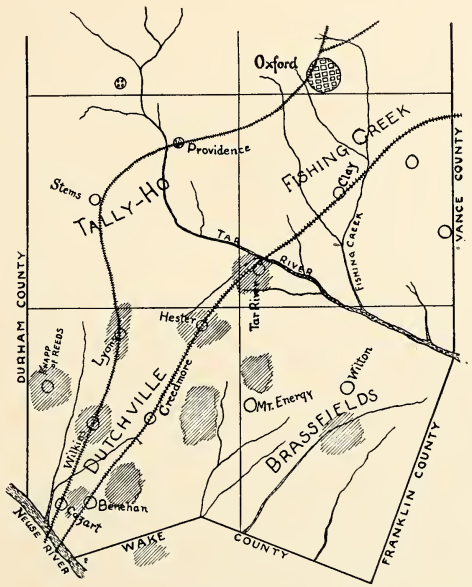


Fig. 12—Map of portion of Granville County showing diseased regions.

On the accompanying map the shaded regions represent places where the disease is now known in North Carolina. In many cases the land in the intermediate country is also sick, and the disease probably exceeds the limits here assigned, though it is positively stated by people who are familiar with the section that no wilt is found except between the Tar and Neuse rivers. Further inquiry may show the disease to be of much wider distribution than is here indicated.

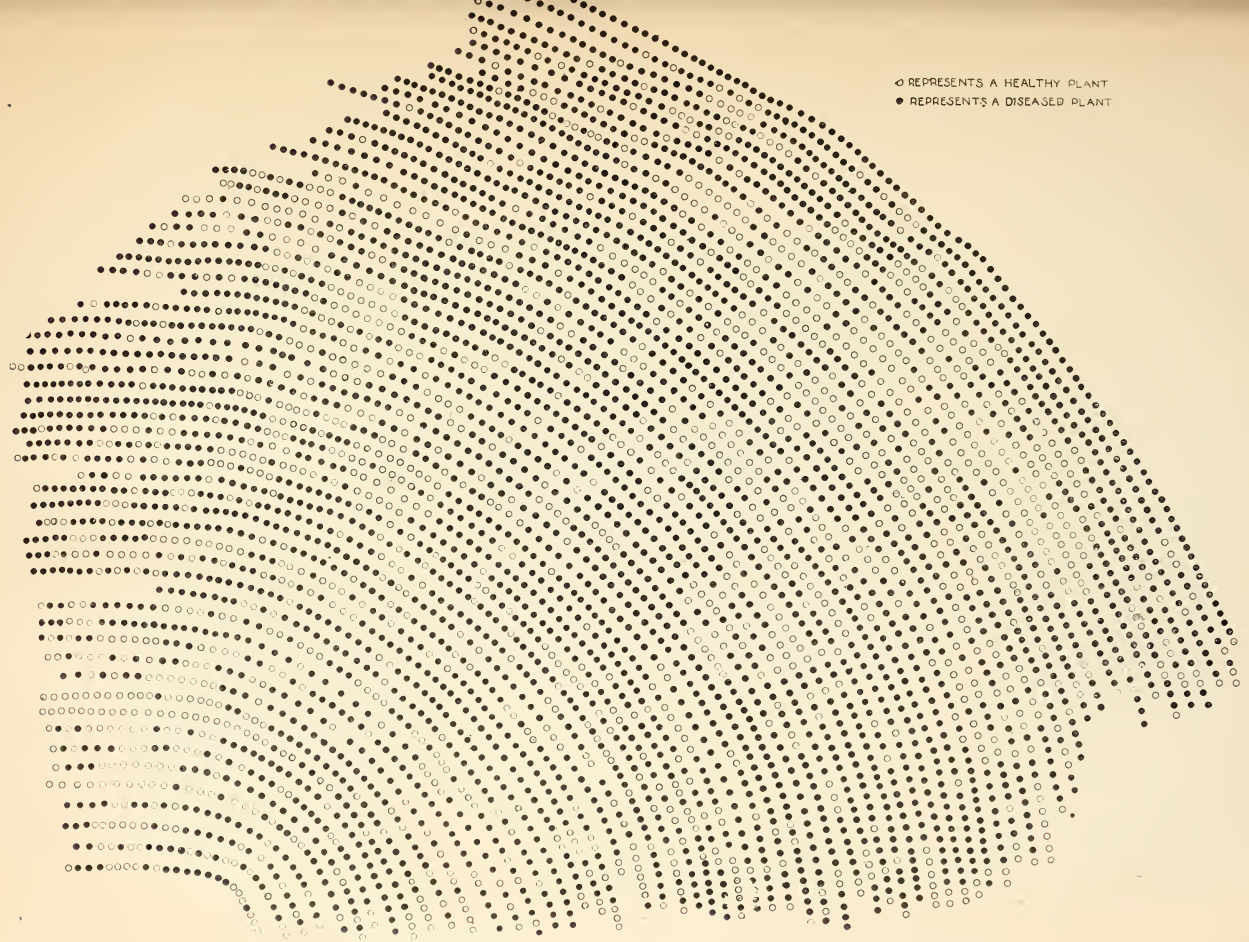


FIG. 13—Map of the field pictured in Fig. 3, showing distribution of diseased plants.

In its bounds as known at present the disease is not of great significance to the State, however great may be its burden to individuals living in the affected sections. It is hardly to be hoped, however, that in the natural course of events the wilt will remain so confined. It has spread and will continue to spread unless checked by intelligent management.

The Cause.

Various theories have been advanced by the farmers as to the cause of the malady. Fertilizers, guano, improper crop rotation, climatic conditions, tillage, worms, bugs, conditions of the seed bed, etc., etc., have all been invoked; but a general concensus of opinion among careful, observant tobacco growers pronounces each of these insufficient to explain the existing conditions. A careful examination of the stem and root fails to reveal the constant presence of any insect enemy.

If portions of black strands from root, stem, or leaf be examined microscopically the vessels are invariably found to be filled with myriads of bacteria.* These are always present in the diseased parts in great multitudes. They are never present in healthy parts. The known facts concerning the spread of the disease as stated above, agree with the idea that it is of bacterial origin. It is therefore strongly presumptive that these germs cause the Granville wilt.

The final death of the plant may be due to either of two causes: the stoppage of food and water supply, through the inability of the diseased roots to longer absorb these from the soil in the case of very badly diseased root systems, or probably more often to a plugging of the water conducting tubes in the woody parts of the stem, thus effectually cutting off the water supply of the plant. A full-sized tobacco plant transpires or evaporates many ounces of water daily from its leaves, and any cause that operates to diminish or stop this supply must inevitably result in a wilting of the foliage.

That the action is of the nature of a plugging is evident in the case of one-sided wilt of a plant or leaf when the blackened strands indicating the plugged water vessels are clearly seen to be those leading to that part of the leaf or stem showing the first signs of the wilt.†

There seems to be no doubt that the efficient cause of this disease is a thrombosis of the vessels by bacteria. Whether these organisms constitute likewise the initial cause, and can, unaided, affect an entrance into the plant can be determined only by more complete study. In the present status of the investigation, in the light of the evidence of both laboratory and field, the only tenable hypothesis is that of bacterial origin, although such a cause can not be considered as posi-

*Small living plants or germs, so small that 25,000 of them placed end to end would reach only an inch.

†The materials on which this study was made were collected at and near Creedmore and Hester.

FIG. 14—A healthy field near Creedmore, N. C.

FIG. 15—A diseased field on similar soil near Creedmore, N. C.

tively established, until the disease has been produced artificially by inoculating a healthy plant with a pure culture of these germs, an operation that has as yet not been possible, owing to lack of plants in suitable condition for experimentation.

Means of Distribution of the Germs.

The germs grow and multiply in the affected plants. Upon the death and disintegration of the plant they are liberated in the soil where they seem to be able to live for considerable time. The immensity of their number in a diseased plant furnishes inconceivable hosts, so that even a few diseased stems, roots, or leaves in the field will stock the soil plentifully with the germs. Infected plants or soil in which infected plants have been or which bears parts of infected plants, can therefore convey the disease to healthy fields.

Instances have been cited in previous pages where the contagion has been spread by WASHING from higher land to lower, so, too, may it be carried by any means which can convey soil from a sick to a healthy field, notably through TOOLS, which have been used on diseased soil. Though apparently reasonably clean, such tools, if they bear even a fraction of a spoonful of infected soil, may carry hundreds of germs and thus start an epidemic in the field next cultivated. The HOOFS of animals or the FEET of laborers, may in a similar way bear the disease-laden soil. WIND passing over an infected field may pick up broken bits of sick tobacco plants or germ-laden soil, and convey these to healthy fields. Infection by wind, however, seems to be rare, possibly because of the germicidal action of the sun's rays upon the surface layer of soil upon which the wind must act. It is still an unanswered question whether the germ can live through the heat of the curing-house. If it can, an additional means of dispersal obtains in the manure made from the refuse stalks and stems derived from such plants.

Length of Life of the Germs in the Soil.

It is unknown how long the germs can live in the soil without their favorite food, the tobacco plant. That they can live from one season to the second season following seems certain. A field slightly affected one year if put to tobacco the second year after will be more seriously diseased, and the affection will grow in destructiveness so long as tobacco be cultivated with so short an intervening period. This seems to prove that the increase of germs in the soil is much more than enough to counter-balance the loss occasioned by the winter season.

If tobacco be planted on an affected field that has had no tobacco for several years, it is found that the field has become more healthful.

The germs have died in the soil, probably for lack of that food to which they are particularly adapted. In one case by rotating the crop so that tobacco did not come again upon the field in fifteen years the disease was completely eliminated. Several cases are known where a rest of five, and even eight years, did not materially restore the soil to health. From the evidence at hand it appears that the germ may live as many as eight, but less than fifteen years in the soil without the tobacco plant. Further evidence upon this point is needed.

Methods of Prevention.

It is hopeless to attempt to cure a plant after it is once diseased. Prevention must be relied upon. With the knowledge that the disease is caused by living germs rational methods may be adopted to prevent its spread.

Prevention of Spreading by Soil.

Any means which can carry soil from a diseased field to a healthy field may spread the disease. One of these ways is by washing. In some cases a field now healthy may be protected from higher land that is infected by proper arrangement of dykes.

A second means of soil conveyance is by tools. A cultivator or a hoe used in an affected field carries myriads of germs. If such a hoe be used in an unaffected field these germs will be distributed and the disease spread. This means of spreading is largely within the control of the farmer. All that is required is such thorough cleansing of tools that no possibility of conveying the germs remains. First, the dirt should be knocked off, then wiped off and the implement finally cleaned by being thoroughly wet with a solution consisting of two per cent formalin or five per cent carbolic acid. It is difficult to insure complete protection against spread by the feet of animals and man, but every possible precaution should be exercised in this particular.

Prevention of Spread by Diseased Plants.

Every diseased plant is veritable culture ground for the germs. Therefore every such plant and every part of such a plant should be destroyed by fire. Pull the plants up by the roots, getting all of the roots possible. Let them dry and then burn them. This precaution in a badly diseased field diminishes the nourishment at the disposal of the germs and will probably enable the land to recover more rapidly. Burning is, however, especially important where but a few plants in a field are affected. Prompt action here may materially lessen the rapidity of spread of the disease in the field. It should be borne in mind that every particle of sick plant burned means the destruction of millions of the germs.

Possibilities of Soil Treatment.

The germs reside in the soil. The possibility of killing them in the soil therefore arises. Experience with other diseases which in a similar way winter in the soil leads to but slight hope that any method of soil sterilization will ever be practicable. This germ is different from others that have been experimented upon, however, and the importance of the problem demands that a thorough trial be made.

The fact that the seed-bed seldom if ever bears diseased plants indicates that the heat generated by burning the bed, suffices to kill the germs. Diseased land could doubtless be made healthy by burning it over in this way, but such a method is clearly out of the question. Some chemical cheap enough to render its use practicable may be found to accomplish the same end, still no great hope of this is to be entertained.

Crop Rotation.

A long rotation of crops, one that will bring tobacco back upon the affected field only after an intervening period of several years, perhaps after a period of eight or ten years, seems at present to be the only recourse for one whose field is now infected. Even with this precaution it is doubtful whether the disease can be completely eradicated.

The tobacco wilt germ has not been proved to be injurious to other crops, and tobacco-sick soil can probably be safely planted with any other crop, with the possible exception of such close relatives of the tobacco as the Irish potato and the tomato and egg-plant.

A Wilt Resistant Kind of Tobacco.

The one means of overcoming the wilt which is most promising to farmers who own affected soil lies in the discovery of some variety of tobacco that will not wilt even when planted upon sick soil. Varieties of cotton that can resist the cotton wilt, and of cow peas that can resist the cow-pea wilt have been discovered. There is similar hope in regard to the tobacco wilt. If several plants grow under the same conditions in infected soil and one of them survive while the others wilt, this survival may be due to a special resistance on the part of the plant which prevents the encroachment of the parasite. Such a plant should be caused to seed, and its seeds saved with great care, since this ability to resist the disease is a character that may be transmitted to the plant's offspring. Seeds from resistant plants should be tested on sick soil, and any plants that prove resistant should again be saved as seed plants. A few years of such selection of seed from resistant plants may result in the development of a race of wilt-resistant tobacco similar to the wilt-resistant cotton and cow peas, which were developed in a similar manner.

Other Wilts.

Bacterial wilts are known to occur among other cultivated plants, notably the Irish potato, tomato and egg plant. Whether these are communicable to the tobacco, and vice versa, is as yet unknown. The diseases have many points in common.

Very similar diseases affect the cotton, cow pea and watermelon, though in each of these cases the wilt is due to an organism (a fungus) distinctly different from anything found associated with the tobacco wilt. In these diseases also the rot of the root is not characteristic, as it is with the tobacco, nor is the plugging of the vessels by bacteria a feature.

Conclusion.

The tobacco wilt is a very serious enemy which not only injures the crop, but also depreciates the value of the land affected, inasmuch as it prohibits the growing of tobacco in the affected soils.

It is a contagious disease, spreading largely through infected soil.

There is a little hope of restoring land that is once affected. The utmost care should be taken therefore to prevent the spreading of the germ by means of infected tools or by any means.

The number of germs should be diminished by cleaning up old fields and by burning all diseased plants in slightly affected fields as soon as they are discovered.

The greatest hope for the redemption of land now affected lies in the development of a variety of tobacco that can resist the disease.

Bulletin No. 189 **December 1903**

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

RALEIGH

Feeding Farm Horses and Mules.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C

CONTENTS.

FEEDING FARM HORSES AND MULES

BY CHARLES Wm. BURKETT

North Carolina imports a good deal of feeding stuffs for her horses and mules. Various kinds of hay and grain materials are annually brought into the State to supply the demand for feeds for working animals. Is this necessary? Must the farmer go out of the State and buy materials for his work horses and mules? Is it true that he can not raise the necessary grain and hay on his farm for feeding his working stock? Since it is true that we do not produce what our horse and mule stock consume, then any discussion that is concerned with the production and feeding of home-grown feeding stuffs is worthy of the most careful and thoughtful consideration.

Since many of our farmers grow cotton and tobacco and trucking crops, they often neglect the growing of hay and grain for live stock. Some say they do this because they can not grow timothy hay and oats, therefore if they are to feed properly their horses and mules they must buy these feeding stuffs.

The whole question hinges on feeding the proverbial horse ration—timothy hay, corn and oats. The real question should be, in case this proverbial ration can not be grown, is there any substitute for it? Are there other feeding stuffs that can be produced that will serve as satisfactorily so as to keep the working stock in good form? This bulletin is concerned in answering this question. A number of feeding stuffs have been used, the greater part of which are home-grown in every section of the State.

Some of them are soil-improvers in their growing; some are heavy yielders in many sections; some are admirably adapted as a part of a system of crop rotation; some are winter crops; some are grown with ease and little labor. They answer the question in a practical manner.

Crops Grown in the State.

Corn for grain, ensilage and stover, and the cowpea for grain and hay can be and now are grown in every part of the State; crimson clover is a reasonably sure crop over much of the State; common red clover is more or less grown, and its acreage can be widely extended; cotton seed meal and bran, excellent and cheap, for the nutrients they contain are available everywhere. These are a few feeding stuffs that can be used for horses and mules, and all can

be produced practically everywhere in the State. They make a practical basis for good, efficient working rations.

The Experiments.

The feeding experiments were conducted through a period of parts of two years, beginning March, 1902, and ending October, 1903. The college horses and mules were used in the experiments during the period. Their weights were taken weekly, and the number of hours work recorded. A number of rations have been compared, consisting of both grain and roughage materials.

The experiments were planned to compare a number of feeding stuffs to determine what ones were most effective in performing the work and in keeping the animals in condition; and at the same time to use such feeds as are readily obtained in the State and from the farm. With but two or three exceptions the materials were grown on the college farm and likewise are available to every farm in the State. The exceptions just mentioned refer to dried blood, tankage and gluten meal.

The comparisons are made in all cases by using animals that were paired in a working team. Thus in all cases the conditions relating to the kind and amount of work are the same; that is, two horses were used as a team, plowing, for instance, with a two-horse plow. They worked side by side, they were driven and handled by the same teamster, and under the same conditions of shelter, water and grooming, and one was fed one ration and the other a different ration. We think, therefore, the comparisons are legitimate, accurate and safe. In discussing the experiments two terms are often used—the period average, and the experimental normal or normal weight.

The latter was obtained by taking the average weight for each animal during the whole experimental period included in the two years. The period average refers to the average weight obtained by taking the average of the special period under discussion.

Cost of Feeding Stuffs.

The feeding stuffs used in the experiments have been rated as follows: Corn $20; bran $20; corn and cob meal $17; wheat 90 cents; oats 50 cents; cowpeas 60 cents; cotton seed meal $24; gluten meal $22; corn ensilage $2; cowpea hay $10; oat hay $10; clover hay $10; corn stover $5; and meadow hay $10.

Comparing Bran and Cowpea Hay.

The first comparison extended through a period of twelve weeks, beginning March 6 and ending May 29, 1902.

The rations are as follows:

RATION I—BRAN RATION.

10 pounds bran.
12 pounds corn and cob meal.
2½ pounds gluten meal.
15 pounds corn stover.
Cost 28.9 cents daily.

RATION II—COWPEA HAY RATION.

10 pounds cowpea hay.
12 pounds corn and cob meal.
2½ pounds gluten meal.
15 pounds corn stover.
Cost 23.9 cents daily.

It will be noticed the only difference between these rations is the substitution of cowpea hay for bran, the other feeding stuffs remaining the same in both. The result of three months feeding is seen in the table following, where the weights of each horse are given.

This trial covers a period of the year that is ordinarily the hardest because of the strenuous effort necessary for spring planting.

TABLE I—*Comparing Bran and Cowpea Hay.*

	RATION I.		RATION II.
Horse.	Daisy.	Date.	Doll.
Weights	1200	March 6	1285
	1156	13	1288
	1170	20	1239
	1175	27	1258
	1131	April 3	1231
	1161	10	1241
	1145	17	1186
	1143	24	1209
	1065	May 1	1253
	1121	8	1225
	1149	15	1271
	1152	22	1277
	1153	29	1302
Period average	1148		1251
Normal	1210		1308
Work done	731		731

It will be seen by the table that Daisy on the bran ration after the first weighing held her own throughout the period. It is true she lost in weight the first week, but after that her weights were more or less stable. This shows the ration was satisfactory in every way. The average weight for the period was 1,148, or slightly under the normal weight. It should be mentioned here that all the animals at the beginning of these experiments were below the experimental normal; all were in better condition and flesh at the end than at the beginning.

The table also shows that where ten pounds of cowpea hay were given to Doll, they proved as valuable for feeding as an equal quan-

tity of bran. In fact, by glancing at the several weighings it will be seen that Doll really weighed at the end of the period more than at the beginning, which shows beyond a doubt that the ration was satisfactory. The cowpea ration was also five cents less in daily cost. This is a matter of considerable importance, and, as a fact, is much in the favor of this feeding stuff for farm horses.

Both of these rations were thoroughly satisfactory, and both are almost wholly home-grown.

Rations Three and Four.

Ration III.	Ration IV.
10 pounds corn and cob meal.	5 pounds corn and cob meal.
15 pounds cowpea hay.	2 pounds gluten meal.
	1 pound cotton seed meal.
	5 pounds cowpea hay.
	12 pounds corn stover.
Daily cost 16.0 cents.	Daily cost 13.1 cents.

These two rations were fed Tom and George, two small-sized mules, from March 6 to May 8. The tables below show the results:

	Ration III.		Ration IV.
Horse.	Tom.	Date.	George.
Weights	767	March 6	777
	746	13	769
	747	20	756
	744	27	765
	762	April 3	727
Average	753		759
Normal	753		779
Work done	179.5		179

On April 3 the rations were reversed and continued till May 8. The results are as follows:

	Ration III.		Ration IV.
Horse.	George.	Date.	Tom.
Weights	727	April 3	762
	750	10	766
	706	17	756
	726	24	744
	740	May 1	696
	745	8	716
Average	732		740
Normal	779		753
Work done	278		255

When fed on ration III, composed of cowpea hay and corn and cob meal, Tom practically held his own, while George gained in weight. On ration IV both lost in weight. The difference is slight, however, and the addition of a couple of pounds of corn and cob meal would likely make stable results and a very satisfactory ration, and still be moderate in cost.

Rations Five and Six.

Roxy and Rhody, two young mules just broken to work, were fed from March 6, 1902, to May 8, the following rations, with weights and results herewith:

Ration V.

4 pounds gluten meal.
4 pounds corn stover.
10 pounds corn and cob meal.
8 pounds cowpea hay.
Daily cost 17.9 cents.

Ration VI.

8 pounds oats.
10 pounds corn and cob meal.
8 pounds cowpea hay.
Daily cost 24.9 cents.

Horse.	Rhody.	Date.	Roxy.
Weights	973	March 6	935
	985	13	940
	975	20	939
	970	27	953
	940	April 3	922
Average	969		939
Normal	1012		966
Work done	195		195

Horse.	Roxy.	Date.	Rhody.
Weights	922	April 3	940
	936	10	956
	918	17	971
	900	24	934
	905	May 1	933
	930	8	936
Average	918		945
Normal	966		1012
Work done	315		280

It will be seen in studying these two tables that while Rhody in ration V lost somewhat in weight, the period average is but four pounds below the weight at the beginning. Roxy, on the other hand, has an average gain of four pounds over the weight at beginning.

When the rations were reversed we find there is a loss in weight, as shown by the averages for both mules. Rhody, on the oat ration, lost 24 pounds on the average, and Roxy on the gluten—corn stover ration—lost 21 pounds. The difference in rations, therefore, is not marked except in cost, which is seven cents in favor of the gluten—corn stover ration. The gluten was not relished by either of these mules; they did not like it, nor would they acquire a taste for it. The difference of cost is worthy of consideration. Where animals can be gotten to eat gluten we think it a splendid feeding stuff. All the other animals used in these experiments readily ate the gluten meal.

On May 8th both rations were changed, the quantity of oats was decreased in the one ration, and bran was substituted for the gluten meal in the other. Clover hay was used as roughage. The following shows the rations and the results:

Ration 7.	Ration 8.
10 pounds clover hay.	10 pounds clover hay.
10 pounds corn and cob meal.	10 pounds corn and cob meal.
1 pound cotton seed meal.	1 pound cotton seed meal.
5 pounds oats.	5 pounds bran.
Daily cost 22.5 cents.	Daily cost 19.7 cents.

Horse.	Roxy.	Date.	Rhody.
	930	May 8	936
	936	15	982
	947	22	976
	942	29	983
Weights	894	June 5	919
	910	12	925
	938	19	921
	936	26	970
	933	July 3	960
Average	929		952
Normal	966		1012
Work done	488		514

Here we see a slight increase in weight with both animals, when the averages are considered in connection with the preceding table. When the weights at beginning and end are considered, we see Roxy gained three pounds and Rhody 24 pounds. All in all, we think the conclusion is warranted that the bran took the place of oats, and at a saving of nearly three cents daily. On July 3 the rations were changed by using oat hay in place of clover hay. The rations, otherwise, remained the same. The results are seen in the table following:

RATION 9.

5 pounds bran.
10 pounds corn and cob meal.
1 pound cotton seed meal.
10 pounds oat hay.
Daily cost 19.7 cents.

RATION 10.

5 pounds oats.
10 pounds corn and cob meal.
1 pound cotton seed meal.
10 pounds oat hay.
Daily cost 22.5 cents.

Horse.	Rhody.	Date.	Roxy.
Weights	960	July 3	933
	950	10	931
	976	17	933
	986	24	967
	1023	31	954
	983	August 7	941
Average	980		943
Normal	1012		966
Work done	181		131

The table shows that both mules increased in weight. Rhody's average has gone from 952 to 980; Roxy's from 929 to 943, the increase being a little greater with Rhody on the bran ration. The difference here is favorable to bran over oats both in respect to cost and increase in weight.

RATIONS ELEVEN AND TWELVE.

Rations similar to those fed to Rhody and Roxy as discussed in the preceding tables, were fed Daisy and Doll immediately on the completion of the experiment where bran was compared with cow-pea hay. The table following shows the results:

RATION 11.

4 pounds bran.
2 pounds cotton seed meal.
10 pounds corn and cob meal.
15 pounds clover.
Daily cost 22.4 cents.

RATION 12.

4 pounds oats.
2 pounds cotton seed meal.
10 pounds corn and cob meal.
15 pounds clover hay.
Daily cost 24.6 cents.

Horse.	Daisy.	Date.	Doll.
Weights	1153	May 29	1302
	1109	June 5	1259
	1196	12	1275
	1172	19	1280
	1186	26	1303
	1184	July 3	1306
Average	1167		1287
Normal	1210		1308
Work done	300		299

It is seen here that while the period average is still below the normal average, there is a gain for Daisy where bran formed a part of the ration. The period average at this time was 1,167, as against 1,148 in the preceding experiment. Doll likewise gained in weight; the period average advanced from 1,251 to 1,287.

It is also noticed when the weighings at the beginning and ending are considered, that Daisy on the bran ration gained 31 pounds, and Doll on the oat ration 4 pounds. From this we can conclude that both rations are satisfactory, though the bran ration is some two cents the cheapest. On July 3 oat hay was substituted for the clover hay. The cost of both rations is the same, since oat hay is here rated at the same price per ton. The table below shows the results:

Ration 13.	Ration 14.
4 pounds bran.	4 pounds oats.
2 pounds cotton seed meal.	2 pounds cotton seed meal.
10 pounds corn and cob meal.	10 pounds corn and cob meal.
15 pounds oat hay.	15 pounds oat hay.
Daily cost 22.4 cents.	Daily cost 24.6 cents.

Horse.	Daisy.	Date.	Doll.
Weights	1184	July 3	1306
	1186	10	1291
	1208	17	1297
	1238	24	1348
	1243	31	1342
	1247	August 7	1331
Average	1218		1319
Normal	1210		1308
Work done			

We note at once an increase with both horses. Here the period average is above the experimental normal in both cases. Surely both rations are satisfactory, or the increase would not be so marked.

In this double period experiment both horses ate readily the cotton seed meal in the rations. The results for the two periods show that bran is a satisfactory substitute for oats. A ton of oats contains 1,014 pounds of digestible nutrients, which cost in these experiments $31.25. A ton of bran contains 1,082 pounds of digestible nutrients, which cost but $20, a saving difference of $11.25 on each ton used. When this fact is considered, we see the force and value of the substitution.

Corn and Cob Meal Versus Shelled Corn.

The feeding of corn and cob meal in comparison with shelled corn, when clover hay was used as a roughage, was tested with Tom and

George from May 8 to July 3, with results as shown in following table:

Ration 15.	Ration 16.
10 pounds corn and cob meal.	10 pounds shelled corn.
10 pounds clover hay.	10 pounds clover hay.
Daily cost 13.5 cents.	Daily cost 15 cents.

Horse.	Tom.	Date.	George.
Weights	716	May 8	745
	734	15	743
	740	22	786
	730	29	788
	731	June 5	723
	692	12	783
	712	19	778
	726	26	781
	738	July 3	780
Average	724		767
Normal	753		779
Work done	402		464

Here the average is below the experiment normal in both, still both weighed more at the end of the test than at the beginning. We are justified in saying that both rations are satisfactory, and also that the corn and cob meal was practically equivalent to an equal quantity of shelled corn. This test was continued from July 3 to August 7, with oat hay as the roughage, and an increase of one pound in quantity of grain for both. The table below shows the results:

Ration 17.	Ration 18.
11 pounds corn and cob meal.	11 pounds shelled corn.
10 pounds oat hay.	10 pounds oat hay.
Daily cost 14.3 cents.	Daily cost 16 cents.

Horse.	Tom.	Date.	George.
Weights	738	July 3	780
	711	10	780
	743	17	789
	745	24	776
	768	31	818
	751	August 7	808
Average	743		792
Normal	753		779
Work done	122		144

Both mules have gained in weight. George's average is above the normal, and Tom's not far below. George also did a little more work. The table shows results slightly in favor of the shelled corn. On August 7 both mules were given clover hay again, with grain the same. Following are the results:

Ration 15.	Ration 16.
11 pounds corn and cob meal.	11 pounds shelled corn.
10 pounds clover hay.	10 pounds clover hay.
Daily cost 14.3 cents.	Daily cost 16 cents.

Horse.	Tom.	Date.	George.
Weights	751	August 7	808
	752	14	791
	745	21	793
	774	28	792
	770	September 4	802
	773	11	808
	787	18	797
Average	765		799
Normal	753		779
Work done	118		241

It will be noticed by comparing the last two tables that Tom's average has advanced 22 pounds and George's 7 pounds. Both are now above the normal and both rations are satisfactory. The three trials point to the conclusion that corn and cob meal is a reasonably fair substitute for shelled corn.

Corn Ensilage.

A number of experiments have been conducted at several of our Stations to examine into the value of corn ensilage for beef and dairy cattle, but little is known of its value or use in horse-feeding.

To test the value of this feeding stuff in horse-feeding, Daisy and Doll were fed for five weeks beginning August 7, 1902. Since both were worked together, and at the same kind of work and under the same conditions, the results here obtained are particularly useful in throwing light on this important subject. The results are seen in the next table. It will be noticed there is a difference of $4\frac{1}{2}$ cents in daily cost to the advantage of the ensilage ration, which is worthy of considerable consideration, especially where several horses are kept, where the usual roughage is not easily obtained, but where corn is grown easily and successfully.

RATION 19.

30 pounds corn ensilage.
10 pounds corn and cob meal.
1 pound tankage.
1 pound cotton seed meal.
4 pounds bran.
Daily cost 18.2 cents.

15 pounds oat hay.
10 pounds corn and cob meal.
1 pound tankage.
1 pound cotton seed meal.
4 pounds bran.
Daily cost 22.7 cents.

Horse.	Daisy.	Date.	Doll.
Weights	1247	August 7	1331
	1201	14	1319
	1202	21	1307
	1234	28	1316
	1244	September 4	1374
	1258	11	1339
Average	1231		1331
Normal	1210		1308
Work done	192		188

Both horses are above the normal in weight. Daisy gained slightly, and Doll easily held her own. Surely the results show conclusively that both rations are satisfactory.

On September 11 it was thought best to continue the test and to use clover hay in place of oat hay, and also to reverse horses and rations. An extra pound of tankage was also used in place of the cotton seed meal. The results are seen below:

RATION 21.

30 pounds corn ensilage.
10 pounds corn and cob meal.
2 pounds tankage.
4 pounds bran.
Daily cost 18.5 cents.

RATION 22.

15 pounds clover hay.
10 pounds corn and cob meal.
2 pounds tankage.
4 pounds bran.
Daily cost 23 cents.

Horse.	Doll.	Date.	Daisy.
Weights	1339	September 11	1258
	1343	18	1204
	1300	25	1265
	1340	October 2	1182
Average	1330		1227
Normal	1308		1210
Work done	98½		93½

Doll has held her own as seen by the period average; Daisy has lost slightly. Both rations are seen by these tests to be satisfactory, and corn ensilage must be considered a worthy feeding stuff for

horse. It was now thought advisable to compare corn and corn ensilage with corn and cowpea hay, the efficiency of the latter ration already having been demonstrated. Following are the results:

RATION 23.

15 pounds cowpea hay.
21 pounds corn on ear.
Daily cost 25.4 cents.

RATION 24.

30 pounds corn ensilage.
21 pounds corn on ear.
Daily cost 20.8 cents.

Horse.	Daisy.	Date.	Doll.
Weights	1182	October 2	1340
	1182	9	1305
	1280	16	1270
	1298	23	1290
Average	1235		1301
Normal	1210		1308
Work done	173		179

We seen that Daisy continues to increase in weight, since the ration is sufficient and furnishes the necessary nutrients. Doll loses steadily in weight, bringing the period average down again, and below the normal. We expected this, since both feeds are low in protein, the ration furnishing too little of this constituent. To correct the loss in weight, two pounds each of bran and cotton seed meal were added to the ration and the same fed to both horses. The results are seen in the next table:

RATION 25.

30 pounds corn ensilage.
21 pounds corn and cob meal.
2 pounds cotton seed meal.
2 pounds bran.
Daily cost 25.2 cents.

Horse.	Daisy.	Date.	Doll.
Weights	1298	October 23	1290
	1290	30	1380
	1300	November 6	1350
Average	1296		1340
Normal	1210		1308
Work done	114		114

The results show that the addition of the grain of a protein nature to the unbalanced one causes Doll to recover her loss quickly. Daisy also has gained in weight.

On November 6 both horses were given the following feeding stuffs, termed here as—

RATION 26.

21 pounds of corn and cob meal.
12 pounds cowpea hay.
9 pounds corn stover.
Daily cost 26.1 cents.

Horse.	Daisy.	Date.	Doll.
Weights	1300	November 6	1350
	1240	13	1302
	1230	20	1297
	1250	27	1330
	1300	December 7	1340
	1250	11	1340
	1270	18	1330
Average	1263		1327
Normal	1210		1308
Work done	306		306

This ration costs more than the preceding, and is not so satisfactory. However, after the first week both horses held their own and gained slightly. The ration is wholly home-grown and satisfactory for winter feeding where work is not constant and hard.

CORN ENSILAGE FOR MULES.

Beginning August 7 these two mules were used for testing the feeding value of corn ensilage. The rations used for the comparison, and the results, are seen in next table:

RATION 27.

25 pounds corn ensilage.
10 pounds corn and cob meal.
1 pound dried blood.
4 pounds bran.
Daily cost 16.5 cents.

RATION 28.

10 pounds clover hay.
10 pounds corn and cob meal.
1 pound dried blood.
4 pounds bran.
Daily cost 19 cents.

Horse.	Rhody.	Date.	Roxy.
Weights	983	August 7	941
	991	14	950
	993	21	985
	986	28	966
	1000	September 4	980
	958	11	980
Average	985		967
Normal	1012		966
Work done	254		203

Both rations are seen to be satisfactory, and both are moderate in cost.

The rations were then changed and are as follows, with weights for the period:

Ration 29.	Ration 30.
25 pounds corn ensilage.	10 pounds cowpea hay.
16 pounds corn and cob meal.	16 pounds corn and cob meal.
Daily cost 16.1 cents.	Daily cost 18.6 cents.

Horse.	Roxy.	Date.	Rhody.
Weights	980	September 11	958
	986	18	1015
	1016	25	1021
	987	October 2	994
	960	9	970
	980	16	998
Average	985		993
Normal	966		1012
Work done	320		294

In this case Roxy held her own on the ensilage ration. Rhody, under same conditions, made decided gain. These two tests show that both mules did well where ensilage formed a part of the ration.

On September 18 Tom and George were each fed ten pounds of corn and cob meal, and for roughage Tom was given corn ensilage and George clover hay. The weighings and other data are given in the next table:

Ration 31.	Ration 32.
25 pounds corn ensilage.	10 pounds clover hay.
10 pounds corn and cob meal.	10 pounds corn and cob meal.
Daily cost 11 cents.	Daily cost 13.5 cents.

Horse.	Tom.	Date.	George.
Weights	787	September 18	797
	766	25	799
	779	October 2	801
	720	9	767
	765	16	796
	794	23	810
Average	768		795
Normal	753		779
Work done	160		311

Both mules have held their own, as seen by the table. The period averages are above the normal averages. Tom has gained three pounds on his average over the previous one, and George has lost four. This is slight indeed, and may be due to difference in amount of work done.

Mary and Sue, two young mules, were purchased the first of August and were used for the test which follows:

Ration 33.	Ration 34.
30 pounds corn ensilage.	10 pounds clover hay.
15 pounds ear corn.	15 pounds ear corn.
Daily cost 15.7 cents.	Daily cost 17.7 cents.

Horse.	Mary.	Date.	Sue.
Weights	1090	August 7	983
	1031	13	954
	1086	21	951
	1083	27	982
	1087	September 4	997
	1101	11	971
Average	1079		973
Normal	1091		984
Work done	240		252

The rations were reversed on September 11 and continued until October 23. The results are seen in the following table:

Ration 33.	Ration 34.
30 pounds corn ensilage.	10 pounds clover hay.
15 pounds ear corn.	15 pounds ear corn.
Daily cost 15.7 cents.	Daily cost 17.7 cents.

Horse.	Sue.	Date.	Mary.
Weights	971	September 11	1101
	987	18	1121
	985	25	1087
	978	October 2	1110
	965	9	1090
	980	16	1095
	1010	23	1112
Average	986		1102
Normal	984		1091
Work done	256		247

In the preceding table it will be noticed that Mary, on ensilage, gained slightly in the end, although her average is somewhat below

the weight at the beginning, when she was unused to work. Sue at this time slightly lost in weight; when, however, she was put on the ensilage ration she gained and changed the period average from 973 to 986. Mary, on the clover hay ration, also gained. From these results and those obtained from feeding Daisy and Doll similar rations, we thought it likely that not enough protein was being furnished in the ensilage ration, so the quantity of ensilage was decreased and two pounds of bran and one pound of cotton seed meal were added. The bran and meal were sprinkled on the ensilage. Here are the results in the following table:

RATION 35.

21 pounds corn ensilage.
15 pounds ear corn.
2 pounds bran.
1 pound cotton seed meal.
Daily cost 18 cents.

Horse.	Mary.	Date.	Sue.
Weights	1112	October 23	1010
	1130	30	1015
	1110	November 6	999
Average	1117		1008
Normal	1090		984
Work done	119		119

Both mules increase in weight and raise the period averages. The ration is a good one in every way.

All things considered, the addition of corn ensilage to a ration improves it. Where it was tried with two horses and six mules, the results were satisfactory in the fullest sense as seen by the preceding tables. The animals were sleek, active, and always in good condition. When we consider the fact that a silo costs but little, and that corn can be produced in every section of the State, from the coast to the mountains, we find at once a partial solution to the problem of feeding farm horses and mules. Corn ensilage and the silo should receive more attention than they have in North Carolina.

COWPEA HAY AND CORN STOVER.

These feeding stuffs have been frequently used in tests heretofore discussed. The attempt has not been made to compare them, one against the other, but to study their value where rational rations are compounded of which they are a part.

On October 16 Roxy and Rhody were fed the same ration, made as follows, with results seen herewith:

RATION 36.

15 pounds corn and cob meal.
1½ pounds cotton seed meal.
10 pounds cowpea hay.
Daily cost 19.5 cents.

Horse.	Rhody.	Date.	Roxy.
	998	October 16	980
	1020	23	996
	1028	30	1004
	995	November 6	1005
Weights	991	13	980
	979	20	955
	1010	27	1000
	1040	December 4	1000
	1020	11	1005
	1015	18	1010
Average	1010		993
Normal	1012		966
Work done	500		500

This home-grown ration, as seen by the table, is thoroughly satisfactory.

Tom and George were fed corn stover as a roughage from October 16 to December 11. The results are seen in the next table:

RATION 37.

10 pounds corn and cob meal.
1 pound cotton seed meal.
10 pounds corn stover.
Daily cost 12.2 cents.

Horse.	Tom.	Date.	George.
	794	October 23	810
	795	30	830
	806	November 6	810
Weights	790	13	801
	770	20	803
	720	27	780
	700	December 4	775
	770	11	790
Average	772		799
Normal	753		779
Work done	203		400

This is an inexpensive ration and satisfactory for winter feeding. It is available to every farmer. The stover thus used takes the place of expensive hay and at no cost to the farmer. Instead of perishing in the fields, as it now does, it could readily find a place in the winter feeding of farm horses and mules.

Comparing Shelled Corn and Corn-Cob Meal.

On January 1, 1903, Daisy and Doll were weighed and fed the following rations, to determine the value, if any, in grinding corn and cob. The results are seen in the following table:

Ration 38.	Ration 39.
21 pounds shelled corn.	21 pounds corn and cob meal.
12 pounds cowpea hay.	12 pounds cowpea hay.
Daily cost 27 cents.	Daily cost 23.8 cents.

Horse.	Daisy.	Date.	Doll.
Weights	1280	January 1	1220
	1270	15	1385
	1250	22	1330
	1260	30	1332
	1260	February 5	1360
	1262	12	1365
	1240	19	1330
	1215	26	1325
	1200	March 5	1310
Average	1248		1329
Normal	1210		1308
Work done	381		335

This table shows conclusively in this trial that corn and cob meal was just as valuable as an equal quantity of shelled corn.

At the same time Rhody and Roxy were put on similar rations, though with smaller quantity of grain. Following are the results:

Ration 40.	Ration 41.
16½ pounds shelled corn.	16½ pounds corn and cob meal.
12 pounds cowpea hay.	12 pounds cowpea hay.
Daily cost 22.5 cents.	Daily cost 20 cents.

Horse.	Rhody.	Date.	Roxy.
Weights	960	Jannary 1	950
	1020	15	1020
	1010	22	1000
	1040	30	1009
	1045	February 5	1040
	1040	12	1122
	1038	19	1015
	1041	26	1011
	1000	March 5	1016
	1019	12	1019
Average	1021		1020
Normal	1012		966
Work done	473		440

Here is a period gain over the last period of 11 pounds for Rhody and 27 pounds for Roxy. The corn and cob meal in this case is as good as an equal quantity of shelled corn. The corn and cob meal is 2½ cents cheaper. Still, both are satisfactory.

On March 12 it was thought advisable to substitute 4 pounds of bran for 6½ pounds of corn, and to use corn stover in place of the cowpea hay. It should be noted that these rations are therefore smaller than the foregoing.

Ration 42.	Ration 43.
10 pounds ear corn.	10 pounds corn and cob meal.
4 pounds bran.	4 pounds bran.
12 pounds corn stover.	12 pounds corn stover.
Daily cost 15.5 cents.	Daily cost 15.5 cents.

Horse.	Rhody.	Date.	Roxy.
Weights	1019	March 12	1020
	990	19	1004
	1035	26	1000
	988	April 2	1010
	985	9	985
	992	16	1012
	990	22	1010
	930	30	970
	1000	May 7	1002
Average	993		1001
Normal	1012		966
Work done	411		426

In this trial the quantity of each feeding stuff was precisely the same. The quantity of corn includes the weight of the cob in both cases. In the one, Rhody left the cob in the manger; Roxy ate the cob, since it was ground. Both mules slightly lost in weight. By comparing the weights at beginning and ending, Rhody, on ear corn, lost 19 pounds and Roxy, on corn and cob meal, lost 9 pounds. By comparing the period averages for this and the preceding period we notice that the loss for Rhody is 28 pounds and for Roxy 19 pounds. The difference here is in favor of the ground corn.

On May 7 clover hay was given in place of stover. The data is shown herewith:

RATION 44.

10½ pounds corn on ear.
4 pounds bran.
16 pounds clover hay.
Daily cost 20.9 cents.

RATION 45.

10½ pounds corn and cob meal.
4 pounds bran.
16 pounds clover hay.
Daily cost 20.9 cents.

Horse.	Rhody.	Date.	Roxy.
Weights	1000	May 7	1002
	1008	14	1006
	994	21	1010
	996	28	995
Average	999		1003
Normal	1012		966
Work done	207		208

Both have slightly gained in weight, the difference, if any, being too small to notice.

Similar experiments were made with Mary and Sue to test the value, if any, of grinding corn. Following are the rations and results:

RATION 46.

16½ pounds shelled corn.
12 pounds cowpea hay.
Daily cost 22.5 cents.

RATION 47.

16½ pounds corn and cob meal.
12 pounds cowpea hay.
Daily cost 20 cents.

Horse.	Mary.	Date.	Sue.
Weights	1005	January 1	926
	1040	15	985
	1100	22	990
	1120	30	980
	1130	February 5	1000
	1132	12	985
	1128	19	990
	1122	26	1000
	1122	March 5	1020
	1120	12	987
Average	1102		975
Normal	1091		984
Work done	449		439

On these rations both mules make decided gains. The corn and cob meal here seems to be as satisfactory as an equal amount of shelled corn. At this point in these comparisons the rations were changed and used here as follows:

RATION 48.

10½ pounds ear corn.
6 pounds bran.
12 pounds corn stover.
Daily cost 17.9 cents.

RATION 49.

10½ pounds corn and cob meal.
6 pounds bran.
12 pounds corn stover.
Daily cost 17.9 cents.

Horse.	Mary.	Date.		Sue.
	1120	March	12	987
	1080		19	970
	1120		26	980
	1115	April	2	975
	1100		9	970
Weights	1126		16	972
	1120		23	975
	1170		30	966
	1170	May	7	980
	1118		14	988
	1130		21	1000
	1125		28	995
	1120			
Average	1103			981
Normal	1091			984
Work done	521			516

The difference is small indeed. Mary weighs just the same at the end as she did at the beginning. Sue has gained 8 pounds.

These tests, taken all together, show a slight gain for the ground corn and cob. In some of the tests the differences were marked; in others, if any at all, they were small. While these tests tend to show the value of grinding corn and cob for feeding horses and mules, they need to be substantiated by further feeding trials. Whether one is justified in grinding or not the writer is not able to say. If a grinding mill is on the premises we think it will pay, but if one is obliged to haul corn any distance to a mill, it is doubtful.

CORN, WHEAT, COWPEAS AND OATS.

These four grain feeds are usually available for feeding horses and mules in North Carolina. The experiments following were conducted in the interest of comparisons and to determine their relative values when fed to working animals.

WHEAT COMPARED WITH COWPEAS.

RATION 50.

8 pounds corn and cob meal.
4 pounds ground wheat.
12 pounds meadow hay.
Daily cost 18.8 cents.

RATION 51.

8 pounds corn and cob meal.
4 pounds ground cowpeas.
12 pounds meadow hay.
Daily cost 16.8 cents.

Horse.	Rhody.	Tom.*	Date.	Roxy.	George.*
Weights	978	729	August 7	974	756
	1010	750	14	1016	792
	990	752	21	996	788
Average	993	744		995	779
Normal	1012	753		966	779
Work done	83	60		83	85

*Tom and George were fed ¾ quantity of ration mentioned.

The table shows a gain for all the mules, hence both rations are satisfactory. The total gain for Rhody and Tom is 35 pounds, and for Roxy and George 54 pounds, a slight difference in favor of the cowpeas.

On August 21 oat hay was given in place of meadow hay, and the quantity increased to 14 pounds daily. The data are shown herewith:

RATION 52

4 pounds ground wheat.
8 pounds corn and cob meal.
14 pounds oat hay.
Daily cost 19.8 cents.

RATION 53.

4 pounds cowpeas, ground.
8 pounds corn and cob meal.
14 pounds oat hay.
Daily cost 17.8 cents.

Horse.	Rhody.	Tom.*	Date.	Roxy.	George.*
Weights	990	752	August 21	996	788
	1020	748	28	1032	799
	1014	766	September 3	1028	790
Average	1008	755		1018	792
Normal	1012	753		966	779
Work done	130	102		130	119

* Tom and George were fed ¾ quantity above ration.

The gain in weight continues for all. The wheat ration has an average gain over preceding period of 15 pounds for Rhody and 11 pounds for Tom, while the cowpea ration has a gain of 23 pounds for Roxy and 13 pounds for George. Cowpeas, as a rule, are cheaper than wheat, and in both of these trials were equal, if not superior, as a feeding stuff for mules.

On September 3 the rations were changed by decreasing the quantity of corn in both rations and increasing the quantity of wheat and cowpeas. The plan and results are as follows:

RATION 54.

8 pounds ground wheat.
4 pounds corn and cob meal.
14 pounds oat hay.
Daily cost 19.4 cents.

RATION 55

8 pounds ground cowpeas.
4 pounds corn and cob meal.
14 pounds oat hay.
Daily cost 15.4 cents.

Horse.	Rhody.	Date.		Roxy.
Weights	1014	September	3	1028
	1012		11	1007
	1000		18	1022
Average	1009			1019
Normal	1012			966
Work done	132			132

By studying this table and the preceding one it will be noticed that there is a gain of one pound for each mule in period average weight. The tables suggest that both rations are quite equal in value, and also that wheat and cowpeas are substitutes equal in value to corn. Wheat is ordinarily more expensive than corn, and therefore is of importance only when the market prices are similar. Cowpeas, on the other hand, improve the soil in their growing and can be economically produced, and at a cost per bushel even more cheaply than corn. Cowpeas and corn fed as concentrates make a safe, practical and efficient grain ration.

On September 18 the rations for Rhody and Roxy were changed again, and the following substituted:

RATION 56.

15 pounds green corn in ear.
5 pounds ground wheat.
14 pounds oat hay.

RATION 57.

20 pounds green corn in ear.
14 pounds oat hay.

Horse.	Rhody.	Date.		Roxy.
	1000	September	18	1022
	1000		25	1000
Weights	1030	October	1	1004
	1012		8	1018
Average	1012			1011
Normal	1012			966
Work done	198			198

In this case Rhody has an average gain over last period of 3 pounds, and Roxy an average period loss of 8 pounds. Here is a slight difference in favor of the wheat in the ration. The cost of the corn-wheat ration is slightly higher than the corn ration.

Oats Compared with Cowpeas.

On August 7 Daisy and Mary were fed different rations for the purpose of comparing oats and cowpeas. The plan and results follow in next table:

Ration 58.	Ration 59.
4 pounds ground oats.	4 pounds ground cowpeas.
4 pounds ground wheat.	4 pounds ground wheat.
4 pounds corn and cob meal.	4 pounds corn and cob meal.
14 pounds meadow hay.	14 pounds meadow hay.
Daily cost 24.4 cents.	Daily cost 20.4 cents.

Horse.	Daisy.	Date.	Mary.
Weights	1160	August 7	1066
	1220	14	1102
	1222	21	1086
Average	1201		1085
Normal	1210		1091
Work done	79		79

On August 21, 14 pounds of oat hay were substituted for the meadow hay.

Weights	1220	September 28	1110
	1216	October 3	1102
	1250	11	1030
	1222	18	1104
	1212	25	1112
Average	1223		1091
Normal	1210		1091
Work done	237		281

The data show that both gained in weight, and that both rations were satisfactory in every sense of the word. The cowpeas used in these tests were bought for 60 cents per bushel (an exceptionally low price for peas), and oats for 65 cents per bushel. The practical suggestion is, that since both proved effective and satisfactory, the

matter of cost must be considered. The oats cost a fraction over 2 cents per pound and the cowpeas 1 cent even. It is easy to see that cowpeas were the most economical and practical feed in this case.

Condition of Animals at Beginning and Ending.

During the time the horses and mules were being used in the experiments discussed in the preceding pages they were under the same conditions of shelter, water, grooming and care. The table below gives the weights of each animal at the beginning and ending for the time the respective animals were under experimentation:

Weights at Beginning and Ending.

	Daisy	Doll.	Tom.	George.	Rhody.	Roxy.	Mary.	Sue.
Beginning—first weighing	1200	1285	767	777	973	935	1090	983
Ending—last weighing	1280	1310	766	790	1012	1018	1112	995
Gain	80	25	...	13	39	83	22	12
Loss			1	...	...	...	...	...
Normal or average for whole period	1210	1308	753	779	1012	966	1091	984

When the period averages are taken, the results are as follows:

Period Weights for Beginning and Ending.

	Daisy.	Doll.	Tom.	George.	Rhody.	Roxy.	Mary.	Sue.
Beginning or first period	1148	1251	753	759	969	939	1079	973
Ending or last period	1248	1329	755	792	1012	1011	1091	981
Gain	100	78	2	33	43	72	12	8
Normal or average for whole period	1210	1308	753	779	966	966	1091	984

Summary.

1. The tests made, and as discussed in the preceding pages, show that the forage crops now grown in North Carolina are adapted to horse-feeding; they are efficient, easily grown and available for every farmer. The tests show it is not necessary to purchase feeding stuffs outside of the State.

2. Cowpea hay is a valuable horse feed. Combined with corn and cob meal it makes a practical working ration. It can also be substituted for bran and oats, providing a reasonable quantity of corn is added to the daily ration.

3. Corn ensilage is a superior feed for horses and mules. One of the most satisfactory rations fed in this series of experiments was composed of 21 pounds of ensilage, 15 pounds of corn, 2 pounds of bran and 1 pound of cotton seed meal. The ration was cheap, efficient and wholesome to the animals.

4. Corn stover is a roughage material that is exceeding valuable for feeding farm horses and mules. It is a good substitute for hay for the winter feeding of horses and mules because of its feeding value, the yield per acre and commercial value.

5. Oat hay when cut while in the milk state is a satisfactory horse feed. When thus harvested it compares favorably with clover hay and cowpea hay.

6. Cotton seed meal can be used to displace a part of the corn or oats in a horse or mule ration. Two pounds of cotton seed meal as a part of the daily rations were fed to horses and mules with satisfaction. This quantity can be fed in a mixture with either grain or sprinkled on ensilage or on hay or stover that has been moistened previously to feeding.

In comparison with other feeding stuffs cotton seed meal, because of its high feeding value, is a relatively cheap feed. Corn stover, corn and cotton seed meal, because of feeding and commercial values, make satisfactory rations for winter feeding of horses and mules, or at other times when on light or moderate work.

Some of the animals in these experiments did not at first relish cotton seed meal. Where animals can be made to acquire the taste, it should be made a part of the daily ration.

7. Tankage and dried blood were used in these tests satisfactorily. The latter is especially valuable when horses are "run down" and thin in flesh.

Further tests are necessary to demonstrate the extent of the feeding of dried blood and tankage to know their fullest efficiency.

8. Bran was used as a substitute for oats and for corn acceptably and successfully. When it can be obtained at a moderate cost it should always find a place in feeding work animals. When corn

and oats, though home-grown, are high commercially, it is often economy to sell part of the corn and oats in exchange for bran, providing the latter is not likewise temporarily high in market value.

9. When the whole ear is ground, making what is termed here corn and cob meal, the same efficiency in work and maintenance of weight in horses and mules follows as where an equal quantity of shelled corn is fed.

10. When corn on the ear was compared with an equal quantity of corn ground, the cob included in the latter, the difference was in the favor of the corn and cob meal, when corn stover was used as a roughage. When clover hay was used as a roughage the difference is not sufficient to note. Whether corn shall be ground or not will depend on the cost in labor and trouble in performing the operation.

11. When wheat and cowpeas were compared as a part of the grain ration, cowpeas were equal to wheat, or slightly better. The cost of production and commercial value must always be considered when either is to be fed in connection with or as a substitute for other concentrates.

12. Cowpeas are a satisfactory substitute for oats in feeding farm horses and mules.

13. Various kinds of feeding stuffs can be used to advantage and with economy in feeding farm horses and mules.

14. There is no so-called "one ration for horses."

15. A mixture of corn and bran, or of corn and cowpeas, or of corn, bran and cotton seed meal, is a good substitute for corn and oats in feeding work animals.

16. Any feeding stuff or combination of feeding stuffs that furnishes the necessary and desirable nutrients at least cost, should be the important consideration in the preparation of rations for farm horses and mules.